Town Of Center

P.O. Box 400 • 294 South Worth • Center, CO 81125 • 719-754-3497(Phone) • 719-754-3379(Fax)

January 25, 2012

Wendi Maez, Co-Administrator
Saguache County
P.O. Box 655
Saguache, CO 81149

Dear Wendi,

The Town of Center wishes to provide this letter of support to the solar electric generating facility proposed to be located on a 4,000 acre site located within Township 41 North, Range 9 East in Saguache County.

The proposed solar project appears to be able to generate more than just electricity in the San Luis Valley. The potential for 40 or more permanent jobs at the site, coupled with a large number of construction workers could provide a positive benefit to Center, as well as the rest of the Valley. Assuming that all environmental concerns can be addressed prior to construction, this would seem to be a worthwhile undertaking with positive benefits.

We appreciate the fact the Board of County Commissioners have chosen to hold their public hearing on this project in our community, and look forward to having a more complete picture of the proposed project and its impacts/benefits.

Regards,

Forrest H. Neuerburg
Town Manager

CITY OF MONTE VISTA
www.cityofmontevista.com
4 Chico Camino in Colorado 81144
City Manager: (719) 852-2692
City Services: (719) 852-5926
Parks & Recreation: (719) 852-4575
Administration: (719) 852-5926
City Hall Fax: (719) 852-6167
Human Resources Fax: (719) 852-6172

Wendi Maez
Saguache County Land Use
PO Box 326
Saguache, CO 81149

January 23, 2012

RE: Support for SolarReserve's 1041 Permit Application

Dear Ms Maez:

By a unanimous vote at their January 19th meeting, the City Council of Monte Vista has chosen to voice its support for SolarReserve and the Saguache Solar Energy Project. We encourage the Board of County Commissioners to grant SolarReserve a timely and appropriate 1041 Permit.

We recognize the following benefits of the project:

- Hundreds of construction jobs, many of which can be performed by local people
- Dozens of full-time operational jobs for a period of 30 years or more, providing long-term career opportunities for our community
- Significant economic growth due to demands for foodservice, hospitality and lodging, materials supply, etc.
- Increased tax revenues that will support our local governments and schools

We believe that this project would be a positive addition to the San Luis Valley and we hope that SolarReserve and Saguache County will proceed.

Sincerely,

Don Van Wormer
Monte Vista City Manager

Town of Saguache Colorado

GATEWAY TO THE SAN LUIS VALLEY

719-655-2232
Fax 719-655-2699
tos417@centrytel.net

January 23, 2012

Saguache County Board of Commissioners
Attention: Wendi Maez
P.O. Box 655
Saguache, CO 81149

Dear Saguache County Commissioners:

The Board of Trustees of the Town of Saguache would like to express support for the proposed project by Solar Reserve, to be located in southern Saguache County. It is the opinion of the Board that the project will be helpful for Saguache County by providing jobs and tax income, and it is our hope that the project is able to move forward.

Sincerely,

Milton Jones
Mayor

Saguache County
Department of Social Services
Jeannie Norris, Director

605 Christy Ave, P.O. Box 215, Saguache, CO 81149
Phone (719) 655-2537, Fax (719) 655-0206
Center Office (719) 754-2308, Fax (719) 754-2630

January 26, 2012

Saguache County Board of Commissioners
Michael J. Spearman, Chairman
P.O. Box 655
Saguache, CO 81149

Re: Solar Reserve Project

Dear Mr. Spearman:

This letter will express support for the Solar Reserve Project currently under consideration by the Saguache County Board of Commissioners. The Department of Social Services is challenged on a constant basis to work with clients in order to remove whatever barriers to their being economically self-sufficient. As you are aware, the unemployment rate for Saguache County remains the second highest in the State of Colorado, and opportunities for employment and training are scarce at best. Our goal is to assist citizens of Saguache County to achieve a level beyond entry level, temporary or seasonal employment.

I had the opportunity to hear a presentation from Mr. Green on behalf of the Solar Reserve Project, in which he indicated that there would be training opportunities and employment for both Saguache County citizens as well as staff which would come in with the company. This would benefit in two areas, being employment for our citizens, and financial reward for those newcomers who will then need housing, supplies, etc.

I therefore, on a personal basis as well as on behalf of the Saguache County Department of Social Services, strongly urge the adoption of this plan to provide clean, renewable energy as well as economic benefit for Saguache County. Thank you for your consideration.

Sincerely,

Jeannie Norris
Director

Wendi Maez

From: DAWN ANDERSON <redawn@msn.com>
Sent: Tuesday, January 24, 2012 4:07 AM
To: wmaez@saguachecounty-co.gov
Subject: Solar Reserve Comments
Attachments: Comments on Solar Reserve Project.pdf

Importance: High

Wendi,

Please see comments attached regarding the Solar Reserve project. I do not think it meets all the criteria that are required for a 1041 approval at this time. Please let me know if you have any trouble opening the attachment and I will re-send, or put it in the body of an email.

Thank you,
Dawn Anderson

January 23, 2012

Comments on the proposed Solar Reserve Project

Dear Commissioners,

As you are aware, in the 1041 Permitting process, there are several criteria that must be met for a project to be approved for a 1041 permit. One of the criteria states:

"o. The nature and location for expansion of the facility will not interfere with any significant wildlife habitat or adversely affect any endangered wildlife species, unique natural resource or historic landmark within the impact area;"

It appears that the **Solar Reserve proposed project does NOT meet the above criteria**.

From the **Wildlife Literature Review**, dated January 2011, submitted by Solar Reserve, they state many unknowns for impacts to wildlife/birds. From the Executive Summary, it states that the effects of the evaporation ponds are unknown, but toxicity to birds is stated as possible. Also, they state that night migrant songbirds may have fatal collisions with the tower. They also state that bird collisions with the heliostats is likely to occur and may be more predominant in water birds. They expect the number to be "low," but no definition of "low" is given. This is a relative term and could be downplaying this concern.

From comments provided by Rick Basagoitia of the Colorado Parks and Wildlife that were posted on your website on January 18, 2012, they state that the 1041 application does NOT satisfy their concerns to wildlife and that the wildlife study conducted for the Solar Reserve Application was underscoped and not representative of the conditions of the San Luis Valley. In addition to dangers to migratory birds, water birds and birds of prey, Mr. Basagoitia's letter states that significant antelope winter range habitat will be lost.

A willingness to work with the developers does NOT, in my opinion, satisfy criteria "o.," where there could be significant impacts to wildlife and many unknowns on the impacts to wildlife, since this project is unprecedented.

Additionally, no responses were available to review from federal wildlife agencies. There are National Wildlife Refuges located in the San Luis Valley, and they are operated under the US Fish and Wildlife Service. Additionally, the San Luis Valley is home to the Great Sand Dunes National Park, operated by the National Park Service. The Wildlife Literature Review mentions that federal wildlife agencies also expressed concerns about this project. All concerns from federal wildlife agencies must be adequately addressed and responses from these agencies should be available for public review.

There are projects similar to this one being constructed in other states. Perhaps the effects could be studied more thoroughly and more data could provide valuable insight on the effects to wildlife from such a large project. Until that data can be collected, the County should **deny** the 1041 Permit and allow Solar Reserve to re-apply if the data warrants the project meets criteria "o." of the 1041 permit.

Another criteria for approval of the 1041 Application:

"e. The nature and location of the facility complies with all applicable provisions of the master plan of this County, and other applicable regional, metropolitan, state, and national plans."

From the Saguache County Master Plan, the following are important to the residents of Saguache County:

"Residents and Stakeholders in Saguache County share common values that are the foundation to creating a desirable future together. They value their high quality of life filled with peace, quiet, and solitude; ***clear, dark, starry night skies; the spectacular views*** *created by wide open spaces surrounded by beautiful mountains; and the high quality of the natural resources and unpolluted environment of the region. They want to maintain the fresh air, clean water, and* ***abundance of wildlife present today into the future****. Agriculture, both livestock and locally grown produce, is an important component of the rural lifestyle and residents want to maintain its viability. As land use patterns are considered, a priority is placed on protecting the mountains, foothills, environmentally sensitive areas such as wetlands and riparian areas,* ***wildlife habitats*** *and corridors, and agricultural lands, especially those irrigated with water rights."*

Additionally, the Master Plan states that residents have concerns about development as industrial-sized solar power plants:

"Residential developments and a proposal for ***industrial-sized concentrated-solar power plants have spurred concerns*** *that this kind of growth could destroy the unique sense of place that defines Saguache County. Some are asking for tighter controls while others resent any land use regulations. Some want no changes in Saguache, wanting it to stay as it is, while others are hoping change will bring opportunity for jobs, more sustainable practices, and improved services."*

While economic growth was the main concern expressed by residents, they also wanted it to be consistent with the values, above. Preserving wildlife habitat came in second:

"Economic growth was the concern Saguache County residents expressed the most during the master plan process. They voiced a clear need for the county to encourage activities that can ensure economic stability for residents ***while remaining consistent with core community values. Preserving open space and wildlife habitat came second, which speaks to a clear need for a master plan which supports development, yet does not threaten what a majority of county residents hold most dear."***

The Master Plan is generally favorable of solar development, but cautions:

"Growth industries recognized as priorities for Saguache County are: agriculture, solar energy development, tourism, and "placed-based development". Because of the growing demand for energy and the potential resources with the area, ***such development must be prioritized and taken seriously.*** *There is an urgency to be addressed as outside development interests may drive development regardless of Saguache County or Valley preferences and interests if commercial viability is perceived". (19)*

The above speaks to the need to designate areas that are and are not suitable for this type of development and potentially place limits on how much can occur.

The Master Plan also acknowledges that not all impacts are beneficial:

"The primary community impacts are two-fold: beneficial ***and nonbeneficial.*** *Assuming a robust and growing market for power, there may be little or no demand for concessions or incentives. Local landowners and governments should work hard to know and negotiate fair and forward looking lease and tax agreements. Most of the economic value from these types of developments will be through these two venues.* ***There will be some impacts during construction and on-going operations. Adverse impacts can be*** *minimal* ***and tied to community preferences.*** *Land will need to be shared (wind), or dedicated (solar). For some,* ***there will be visual pollution and concern over wildlife; and there are increasing concerns that these developments will impact the migrating and local bird populations.*** *When considering locally based developments, great care should be taken given market fluctuations, major capital requirements, and the complexities of such development". (20)*

Basically, it appears that the Master Plan speaks to concerns of the residences for a project such as the proposed Solar Reserve project. These concerns must be taken seriously and adequately addressed. Saguache County residents appear to place much value on wildlife (see above discussion) and visual impacts.

The proposed Solar Reserve project will have adverse visual impacts to residents and visitors to the San Luis Valley if it is approved. A separate and independent study by the County should be conducted to explore the visual impacts of this project. Other large structures being constructed in other states, but in a similar landscape, suggest that the simulations included in Solar Reserve's 1041 Application are not accurate. These towers would be visible for miles. The proposed size of the towers is higher than any other tower in the area and it appears that it is not compatible with what is deemed important in the Master Plan, as the views will be obstructed. The eye is drawn to structures such as this if they were to be built in this area, so simply "not looking at it" is nearly impossible.

The project, as it is proposed, should be **denied**, based on the visual impacts and not meeting the criteria of item "e." The applicant could re-apply if additional data from similar projects and an independent visual impact study show that the project is feasible without destroying the viewshed.

There are also ways of reducing visual impacts. One way is to reduce the scale of the project. First, the County should not approve TWO of these towers. If one tower were approved, the County could reject the second one if the visual impacts are too severe. Another option, would be to reduce the size of the project to a tower height that is consistent with other towers approved in the San Luis Valley (maybe up to 200 feet?). A smaller tower height may have fewer adverse impacts to wildlife, as well.

In addition to the Solar Reserve Application, a **Draft Solar Reserve Development Agreement** has been posted on the Saguache County website. Based on the above, the application, for the proposed project, as submitted, should be **denied**. However, if Solar Reserve were to re-apply in the future with a more suitable plan, and agreement would be necessary. The Draft Agreement does not contain any provisions for decommissioning the site. The County should consider adding this to the Agreement. Since many changes can occur during the development of the project, any permits the County grants for such a project should have some date of expiration. A project should have to go back to a full 1041 review if time passes, such that conditions change or new information is found that violates one of that the criteria for approval. Enforcement provisions of the County should also be included. A fine and enforcement structure should be clearly stated and implemented if the developer is in violation of any of the 1041 approval criteria. The County should have the right to revoke the permit if the violations are not corrected or are too severe and result in the health, safety and general welfare of the County or its inhabitants to be jeopardized.

As a supporter of solar energy development, I believe there is a better way. Distributed and smaller solar projects can be approved with minimal to no adverse impacts, provide jobs and an economic boost. This is the path forward that Saguache County should be embracing instead of unprecedented large industrial-scale solar projects.

Thank you for taking the time to consider my comments on this solar project.

Sincerely,

Dawn Anderson
Richard Anderson
Saguache County property owners
Members of SLVRCA

Wendi Maez

From: DAWN ANDERSON <redawn@msn.com>
Sent: Thursday, January 26, 2012 5:02 AM
To: wmaez@saguachecounty-co.gov
Subject: Additional Comments on proposed Solar Reserve project

Wendi,

I wanted to provide some additional comments on the proposed Solar Reserve project, in the form of this email. Please let me know that you have received it. Thanks!

Dear Commissioners,

The proposed Solar Reserve project is to build a massive thermal solar power plant using a larger "power tower" and heliostat mirrors and using "molten salt" (potasium nitrate and sodium nitrate) to store the heat. Having just taken my 8 hour annual refresher of Hazardous Operations Emergency Response (HAZWOPER) training, I began thinking about this project, from that perspective. One thing that is necessary for an approval of this project is to protect the safety of the County residents and visitors. I do not know how much training police, fire and EMT responders in Saguache County have received (the application just says they interviewed them and determined no additional training is necessary). This concerns me because safety is often downplayed or reduced to save money because "it is unlikely" to happen. In one video we saw, responders in a rural area in West Virginia were only required to have 4 hours of this type of training and no renewals. When an emergency occured, even the fire department did not know what to do. The full 40-hour HAZWOPER training should be mandatory for all county personnel that has the potential to respond to an emergency at the plant, especially when considering unprecidented solar plants, such as the one Solar Reserve is proposing. There may be additional training required for first responders and all training should be updated annually as the refresher courses.

Solar Reserve and the County should be required to come up with the worst case scenario that is possible at a facility such as this and make a detailed Emergency Response Plan. Some things that must be addressed in such a plan include, but are not limited to:

- Responding to a fire resulting in injuries from heat and chemical burns.
- Responding if a fire at the plant also starts a wildfire, in worst case, high wind conditions.
- Responding if a wildfire in high wind conditions is approaching the plant.
- Considerations of medical helicoptor landing sites - does Solar Reserve need to install a landing pad?
- Considerations of cell phone coverage. Cell phone coverage should be tested on the entire proposed site, and if coverage is not adequate, Solar Reserve should be required to subscribe to more reliable satelite phones.
- Considerations should be made of exit and escape routes. How many exits out of the facility are they planning? Is it enough?

This type of detailed plan, without vague, all-inclusive statements must be required before any approval can be made. A detailed cost estimate should also be included if this will be a cost burden placed on the county for additional training.

Thank you for considering the above comments,

Respecfully submitted,
Dawn Anderson
Saguache County Property Owner
Member of SLVRCA

Wendi Maez

From: Joy Hughes <joy@solargardens.org>
Sent: Tuesday, January 24, 2012 11:50 AM
To: Wendi Maez
Subject: Fw: [EXTERNAL] Visual impacts of solar power towers?

Joy Hughes, Founder, Solar Gardens Institute http://www.solargardens.org
CEO, Solar Panel Hosting LLC http://www.solarpanelhosting.com
(719)207-3097 direct

From: "Ho, Clifford K" <ckho@sandia.gov>
Date: Tue, 24 Jan 2012 17:57:03 +0000
To: joy@solargardens.org<joy@solargardens.org>
Subject: RE: [EXTERNAL] Visual impacts of solar power towers?

Hi Joy,

We should be able to use our models to evaluate ocular impacts of different-sized systems. I will be very busy until the second week of February, so I won't be able to address your concerns until then.

Best regards,

-Cliff

Cliff Ho, Ph.D.
Concentrating Solar Technologies Department
Sandia National Laboratories
P.O. Box 5800, MS-1127
Albuquerque, NM 87185-1127
(505) 844-2384
ckho@sandia.gov
www.sandia.gov/csp

From: joy@solargardens.org [mailto:joy@solargardens.org]
Sent: Monday, January 23, 2012 5:51 PM
To: Ho, Clifford K
Subject: [EXTERNAL] Visual impacts of solar power towers?

Clifford,

It was with great interest I downloaded and read your paper on glint and glare hazards. We are evaluating a solar tower project in the San Luis Valley of Colorado - it is a much larger project than you model (height ~200m, receiver height ~30m, diameter ~20m). I'm interested in seeing if we could plug these numbers directly into your model.

We also experience frequent Fata Morgana mirages that magnify objects on the horizon. The site is close to Great Sand Dunes National Park and the Sangre de Cristo Wilderness. It occurs to me that glare not bright enough to cause an afterimage might be distracting enough to appreciably mar scenic beauty.

Many thanks,

Joy

Joy Hughes
Founder, Solar Gardens Institute http://www.solargardens.org
CEO, The Solar Panel Hosting Company, http://www.solarpanelhosting.com

Wendi Maez

From: Joy Hughes <joy@solargardens.org>
Sent: Tuesday, January 24, 2012 11:51 AM
To: Wendi Maez
Subject: Glare Research

I also entered a copy of the research paper in the record and would like to be qualified as an expert.
Joy Hughes, Founder, Solar Gardens Institute http://www.solargardens.org CEO, Solar Panel Hosting LLC
http://www.solarpanelhosting.com
(719)207-3097 direct

Wendi Maez

From: Joy Hughes <joy@solargardens.org>
Sent: Thursday, January 26, 2012 6:59 AM
To: Wendi Maez
Cc: Linda Joseph; Sam Pace
Subject: Solar Reserve Comment

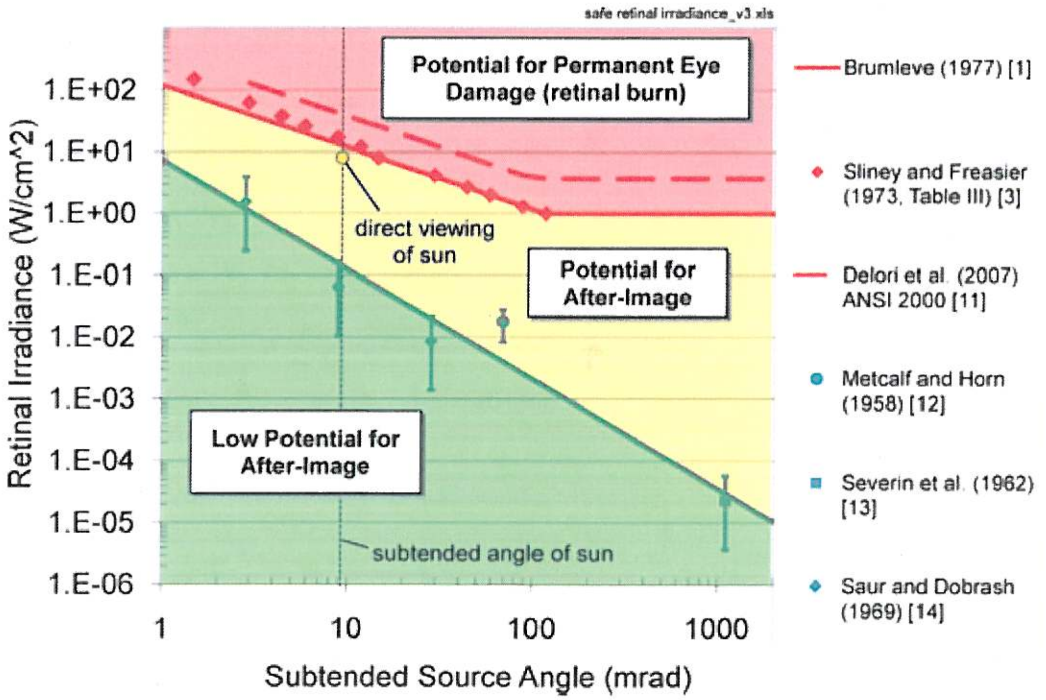
Decision MUST be delayed until an independent visual impact analysis can be performed.

Not enough time has been given for cross examination (30 minutes) or Joy Hughes, Founder, Solar Gardens Institute http://www.solargardens.org CEO, Solar Panel Hosting LLC http://www.solarpanelhosting.com
(719)207-3097 direct

Visual Impacts –

The towers would be located in the center of the San Luis Valley west of Great Sand Dunes National Park, and would impact the Sangre de Cristo Wilderness, and the Sangre de Cristo National Heritage Area. The towers would be almost as high as the dunes themselves. Such a project would be more than just an eyesore, a desecration of monumental proportions – it appalls me that it is even being considered in such a scenic area. Solar Reserve cannot mitigate the visual impact and thus the project should be moved outside the valley where transmission is available, perhaps at the site in Pueblo County where a nuclear plant was rejected.

In August 2011 the Journal of Solar Energy Engineering published a paper titled "Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation." The paper models a solar tower half the size of Solar Reserve, and concludes "this irradiance will not cause irreversible eye damage, but it is sufficient to produce a temporary after image if one looks directly at the source". The safe distance for the smaller was calculated to be 1840 meters – larger than the radius of Solar Reserve's proposed mirror field. Scaling up to Solar Reserve's size would give a "safe" distance of about two miles, and a mirage that magnified the size of the bright spot tenfold would increase that to over 6 miles.



I hold a Master's Degree in Computer Graphics from UC Santa Cruz, and am qualified in the subject matter of the research paper, including specular and diffuse reflections, atmospheric attenuation, and the ray-tracing models used to simulate visual impact.

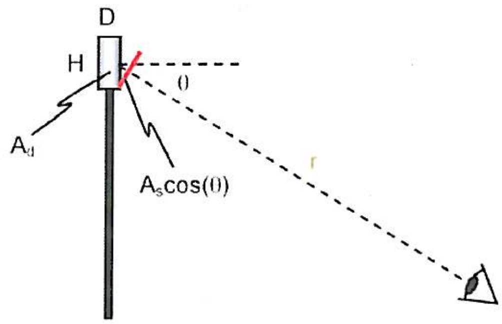


Fig. 6 Illustration of parameters used for diffuse-reflection calculations (e.g., viewing an external cylindrical receiver on top of a tower)

$$E_d = L_d \Omega \frac{A_s \cos(\theta)}{A_p} \quad (17)$$

where A_p is the pupil area (m^2), Ω is the solid angle (sr) subtended by the pupil of the eye as viewed from the source, A_s is the area of the source visible to the observer (m^2), and θ is the angle between the surface normal of the source and the line of sight between the source and the observer. The product of $A_s\cos(\theta)$ is the visible area projected toward the viewer (see Fig. 6) and is the area upon which the radiance, L_d, is based. Note that as θ increases to 90

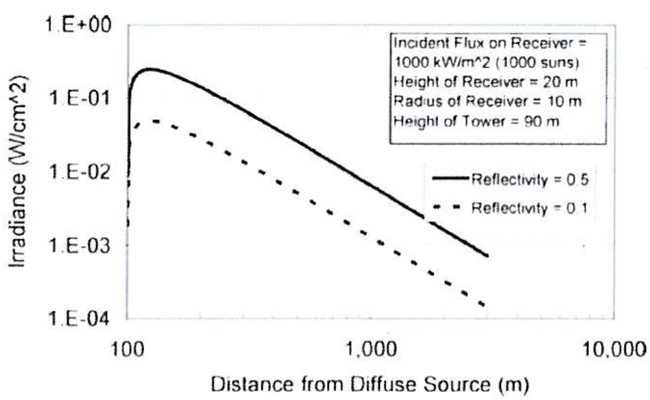
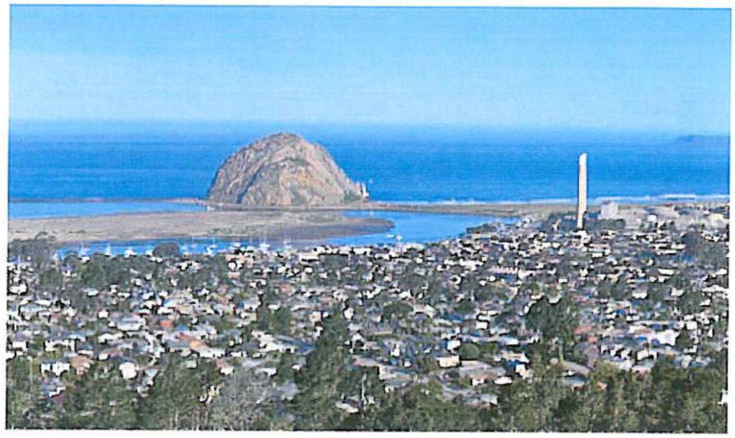


Fig. 7 Irradiance at the cornea as a function of distance from a diffuse source with different reflectivities

I have submitted the Sandia paper into the 1041 comment record and contacted the author, Clifford Ho. He kindly offered to run his code to simulate the Solar Reserve tower, but not until the second week of February. **Any approval must be contingent on an appropriate review of this critical data.**

Even if the brightness of the towers were not sufficient to cause temporary spot blindness, it would still be distracting enough to mar the valley's vistas throughout the entire valley every moment that the sun shines for at least the next 50 years.

The smartest thing for us to do is to wait until the Crescent Dunes tower is operational, and then see for ourselves.



Morro Bay, California is the site of a spectacular 576-foot volcanic plug. In the 1950s Dynergy built a gas-fired power plant with 450-foot stacks. Anyone who visits the town can't help but notice. Now, over 50 years since the stacks were built, a lengthy process is underway to figure out how to dismantle them. Did the power plant lead to economic growth? In 2000, per capita income in Morro Bay was $21,687. In Pismo Beach just to the south income was 42% higher, and in Cambria, the neighboring town to the north, it was 36% higher. It's hard to say if the eyesore stunted Morro Bay's tourist economy, though – power plants are typically built in lower income areas.

Follow the BLM's lead and allow no power towers in the San Luis Valley.

Make any final approval contingent on an independent study on visual impacts.

Make any final approval contingent on observation of an operational Crescent Dunes project to validate Solar Reserve's claims.

Cost Impacts – In the last four years, the cost of ordinary solar panels has plummeted by 75%. The installed cost per watt of solar photovoltaic (PV) is approximately half that of concentrated solar power (CSP). In the Mojave desert, many CSP projects have been converted to PV or abandoned completely. The only CSP projects under construction are those supported by Department of Energy loan guarantees (the same program used by ill-fated Solyndra). Solar Reserve received a loan guarantee of $773 million for its Crescent Dunes project.

Colorado's renewable energy standard requires that ratepayers' bills are raised by no more than 2% to support renewable energy. There is a loophole (HB 10-1001 section 123) that exempts "demonstration" projects from this rate cap. I doubt it was the intent of the legislature to allow for a billion dollar project to be added to ratepayers' bills, but this is what is being contemplated.

There would be an additional cost to ratepayers of approximately $400 million, which would include energy storage. We could buy a lot of backup power and batteries to support the grid, protect crops and potato warehouses, and provide resilience and reliability with that kind of money! 6 hours of storage for a solar PV plant of similar size, or 24 hours using the projected costs of zinc-air batteries.

In the incredibly optimistic case where 50 local people get jobs at $50,000 a year for 20 years, the valley would see $50 million in wages. That's a pretty woeful ratio of corporate pork to a smaller benefit for the valley.

Farm land – the proposed site is some of the best farm land in the valley and is currently serving to grow vegetables for people. Over 1 billion people in the world go hungryRather than fallow the land as part of the sub-district process, we should learn to irrigate other parcels more efficiently and keep this land in production.

Birds – Birds could be attracted to the thermal produced by the hot spot at the top of the tower, then vaporized by concentrated sunlight. More likely, they would collide with the mirrors.

Solar Reserve has not followed the 2010 Fish and Wildlife Service protocol for Golden Eagles. Solar Reserve has proposed an "adaptive" management plan - I guess this means "we'll try stuff after the tower is built and see if they work."

Solar reserve's representatives have also stated that global warming would have a greater impact on birds. This is a false argument when cost-effective alternative locations and technologies exist. This attitude would justify any environmental harm in the effort to stop global warming, even sacrificing our sensitive valley.

Distributed Solar Plus Storage Plan – HB 10-1001 defines distributed renewable energy projects as less than 30 Megawatts in size, and requires 3% of Colorado's energy to be sourced from such mini power plants. The Community Solar Gardens Act provides for community owned solar arrays with local subscribers. Solar Gardens are currently in a pilot phase of 6 Megawatts per year, and demand will certainly exceed supply – the Commissioners should support a plan to increase the distributed carve-out to 15% and the solar gardens program to 125 Megawatts per year.

In California, Jerry Brown has proposed 12,000 Megawatts of distributed power. California bill SB843 would allow for up to 5,000 Megawatts of solar gardens, replacing failed desert projects. A proportionally large plan for Colorado would give us 1,000 Megawatts of solar gardens.

I founded the Solar Panel Hosting Company (SPH) to provide a chance for San Luis Valley residents to keep a small solar array on their property. Several dozen sites in the valley have been identified. SPH has since expanded and has ten sites for community solar gardens under contract in Colorado, including three in the SLV. Locally owned energy sources can provide three times the economic benefit of distantly owned power, according to John Farrell of the Institute for Local Self Reliance.

Last year the Solar Gardens Institute presented to the Saguache County Commissioners a proposal for 150 Megawatts of distributed solar at substations and on irrigation corners, with 25MW in each county. The plan includes local storage, baseload, and emergency power. This would produce enough power to run the existing power lines over Poncha Pass northwards during the day, requiring only minor upgrades to transmission.

SPH has signed a letter of intent to develop a factory for the assembly of modular solar racking systems to supply systems throughout the San Luis and Arkansas Valleys. The factory will be located in Saguache, if an appropriate site can be found.

Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation

Clifford K. Ho
e-mail: ckho@sandia.gov

Cheryl M. Ghanbari

Richard B. Diver

Concentrating Solar Technologies Department,
Sandia National Laboratories,
P.O. Box 5800,
Albuquerque, NM 87185-1127

With a growing number of concentrating solar power systems being designed and developed, the potential impact of glint and glare from concentrating solar collectors and receivers is receiving increased attention as a potential hazard or as a distraction for motorists, pilots, and pedestrians. This paper provides analytical methods to evaluate the irradiance originating from specularly and diffusely reflecting sources as a function of distance and characteristics of the source. Sample problems are provided for both specular and diffuse sources, and validation of the models is performed via testing. In addition, a summary of safety metrics is compiled from the literature to evaluate the potential hazards of calculated irradiances from glint and glare for short-term exposures. Previous safety metrics have focused on prevention of permanent eye damage (e.g., retinal burn). New metrics used in this paper account for temporary after-image, which can occur at irradiance values several orders of magnitude lower than the irradiance values required for irreversible eye damage. [DOI: 10.1115/1.4004349]

1 Introduction

Assessment of the potential hazards of glint and glare from concentrating solar power plants is an important requirement to ensure public safety [1–3]. Glint is defined as a momentary flash of light, while glare is defined as a more continuous source of excessive brightness relative to the ambient lighting. Hazards from glint and glare from concentrating solar power plants include the potential for permanent eye injury (e.g., retinal burn) and temporary disability or distractions (e.g., after-image), which may impact people working nearby, pilots flying overhead, or motorists driving alongside the site.

Applications and certifications for solar thermal power plants require an assessment of "visual resources" at the site (e.g., Refs. [4–8]), but rigorous and uniform treatment of glint and glare are lacking. Several previous studies [1–3] investigated the impact of specular reflections using permanent eye damage as a metric. The purpose of this paper is to provide a general assessment method that can be used to evaluate potential hazards of glint and glare for all of the primary concentrating solar power technologies: (1) power-tower systems, (2) linear concentrator systems (e.g., parabolic troughs, linear Fresnel), and (3) dish/engine systems. In particular, this paper provides analytical solutions to evaluate the irradiance originating from both specularly and diffusely reflecting sources as a function of distance and characteristics of the source. In addition, tests were conducted at the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories to validate the models. Modeling results (analytical and ray-tracing) were compared to the data, which showed an excellent agreement. The measured and/or calculated irradiances can be compared against the compiled safety metrics to determine safe perimeter zones or regions where personal protective equipment may be needed for short-duration exposures.

2 Review of Ocular Safety Metrics

This section summarizes the ocular safety metrics introduced by Ho et al. [9] for short-term exposures of bright light. Two variables are required for the ocular impact assessment: the retinal irradiance and the subtended angle (size) of the glare source. The retinal irradiance can be calculated from the total power entering the pupil and the retinal image area. The diameter, d_r, of the image projected onto the retina (assuming circular images) can be determined from the subtended source angle (ω), which can be calculated from the source size (d_s), radial distance (r) between the eye and the source, and the focal length of the eye ($f \cong 0.017$ m [3]), as follows (see Fig. 1):

$$d_r = f\omega \quad \text{where } \omega = d_s/r \tag{1}$$

If the irradiance at a plane in front of the cornea, E_c (W/m^2), is known, the power entering the pupil can be calculated as the product of the corneal irradiance and the pupil area (the daylight adjusted pupil diameter, d_p, is $\sim$2 mm). The power is then divided by the retinal image area and multiplied by a transmission coefficient, $\tau(\sim 0.5)$ [10], for the ocular media (to account for absorption of radiation within the eye before it reaches the retina) to yield the following expression for the retinal irradiance:

$$E_r = E_c\left(\frac{d_p^2}{d_r^2}\right)\tau \tag{2}$$

It should be noted that Brumleve [1] includes an additional coefficient (ν) to account for the fraction of solar irradiance between 400 and 1400 nm, but this has been included in the transmission coefficient, τ, above. As an example, the retinal irradiance caused by viewing the sun directly can be calculated using Eqs. (1) and (2) with $E_c = 0.1$ W/cm^2, $d_p = 0.002$ m, $f = 0.017$ m, $\omega = 0.0094$ rad, and $\tau = 0.5$, which yields a retinal irradiance, E_r, of $\sim$8 W/cm^2. The ocular parameters are taken from Refs. [1] and [3]. Note that

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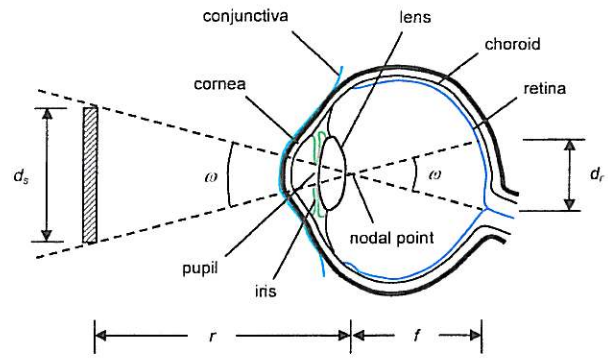

Fig. 1 Image projected onto the retina of the eye

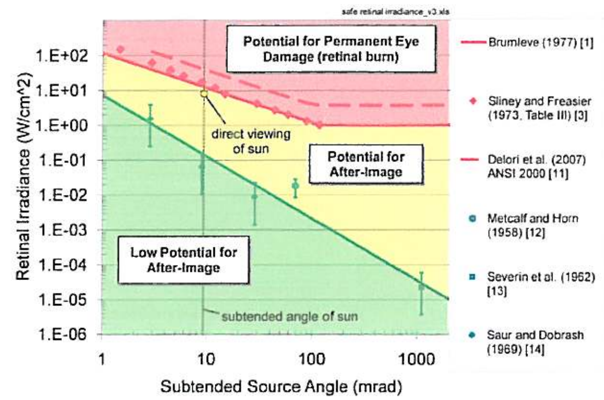

Fig. 2 Potential impacts of retinal irradiance as a function of subtended source angle. Data for irreversible eye damage are from Refs. [1,10,11] for 0.15 s exposure (typical blink response time). Data for temporary after-image are from Refs. [12–14].

the retinal irradiance is significantly higher than the irradiance at the entrance of the eye. The calculated irradiances and thresholds used to determine ocular impacts assume a standard solar spectral distribution (ASTM G173-03), where the majority of the energy and short-duration exposure impacts are due to radiation within the visible spectrum (~380 to 800 nm). Longer-term exposures (e.g., for worker safety) may be additionally concerned with radiation in the ultraviolet and infrared spectra.

Figure 2 summarizes the potential impact of different retinal irradiances as a function of subtended source angle for short-term exposures. Three regions are shown: (1) potential for permanent eye damage (retinal burn), (2) potential for temporary after-image (flash blindness), and (3) low potential for temporary after-image. If the retinal irradiance is sufficiently large for a given subtended source angle, permanent eye damage from retinal burn may occur [3,10,11]. Note that as the subtended source angle increases, the safe retinal irradiance threshold decreases. For a given retinal irradiance, a larger subtended source angle yields a larger retinal image area and delivers a greater power to the retina that cannot be as easily dissipated from the perimeter of the "hot" retinal image as with a smaller image area. Brumleve provides a lower threshold for the retinal irradiance corresponding to permanent eye damage using data from Ref. [3]

$$E_{r,\mathrm{burn}} = 0.118/\omega \quad \text{for } \omega < 0.118 \text{ rad} \tag{3}$$

$$E_{r,\mathrm{burn}} = 1 \quad \text{for } \omega \geq 0.118 \text{ rad} \tag{4}$$

where $E_{r,\mathrm{burn}}$ is the retinal burn threshold (W/cm^2) and ω is the subtended angle (rad). Below the retinal burn threshold, a region exists where a sufficiently high retinal irradiance may cause temporary after-image or flash blindness, which is caused by bleaching (oversaturation) of the retinal visual pigments [3]. When this occurs, a temporary after-image appears in the visual field (e.g., the effect after viewing a camera flash in a dim room). The size and impact of the after-image in the field of view depend on the size of the subtended source angle. For a given retinal irradiance, smaller source angles yield smaller after-images, and the potential impact is less. In Fig. 2, data from Refs. [12–14] were used to fit a lower threshold for potential after-image effects. In Refs. [12–14], people were subjected to different source luminances, and their recovery time was recorded. The minimal retinal irradiance based on the illuminance[1] and subtended source angle that yielded at least 1 s of after-image is shown in Fig. 2. Error bars represent uncertainty in the pupil diameter (2–8 mm) [13,14] and variability in subject response [12]. A fit corresponding to these data that yielded the minimal retinal irradiances that caused an after-image is as follows:

$$E_{r,\mathrm{flash}} = \frac{3.59 \times 10^{-5}}{\omega^{1.77}} \tag{5}$$

where $E_{r,\mathrm{flash}}$ is the threshold for potential after-image (W/cm^2) and ω is the subtended source angle (rad). Values of retinal irradiance below $E_{r,\mathrm{flash}}$ have a low potential for after-image impact. Note that, as plotted in Fig. 2, a brief direct viewing of the sun (0.15 s) has a high potential for producing after-image effects.

3 Modeling Approach

This section presents analytical methods for calculating irradiance caused by specular and diffuse reflections of sunlight as a function of distance and other characteristics of the source. Specular reflections occur from polished mirror-like surfaces so that the reflected angle is equal to the incident angle relative to the surface normal. Diffuse reflections occur from uneven or rough surfaces that scatter the incident radiation such that the radiance is approximately uniform in all directions (see Fig. 3). The following sections provide methods to calculate the irradiance from specular and diffuse reflections. Once the irradiance is determined, the equations in the previous section can be used to calculate the retinal irradiance for comparison against the safe retinal irradiance metrics presented in Fig. 2.

3.1 Analytical Model of Specular Reflections.

Direct specular solar reflection from mirrors can cause glint and glare hazards when heliostats are in standby positions (reflecting the sun at locations other than the receiver). Specular solar reflections from dishes and parabolic troughs can cause glint and glare hazards when the collectors are in off-axis positions (e.g., when moving from a stowed position to a tracking position). For parabolic troughs, glint and glare from specular reflections can also occur when the sun is low in the horizon and aligned with the axis of the trough, causing reflected rays to spill from the end of the trough.

3.1.1 Point-Focus Collectors. An analytical model of beam irradiance resulting from specular solar reflections from a

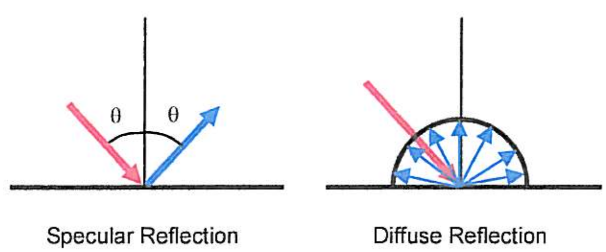

Fig. 3 Illustration of specular versus diffuse reflections

[1]The ratio of spectrally weighted solar illuminance to solar irradiance at the earth's surface yields a conversion factor of ~100 lumens/W.

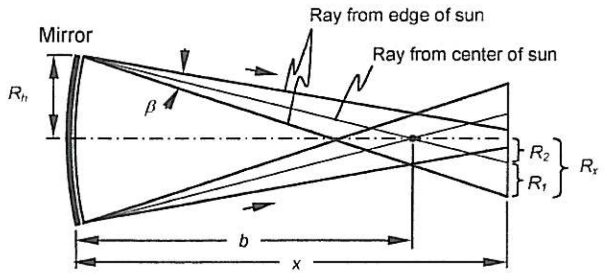

Fig. 4 Geometry of specular solar reflections from a focused mirror where *b* is the focal length, R_h is the radius of the mirror, β is the beam divergence angle, and R_x is the radius of the beam cross section at distance, *x*, from the mirror (adapted from Ref. [1])

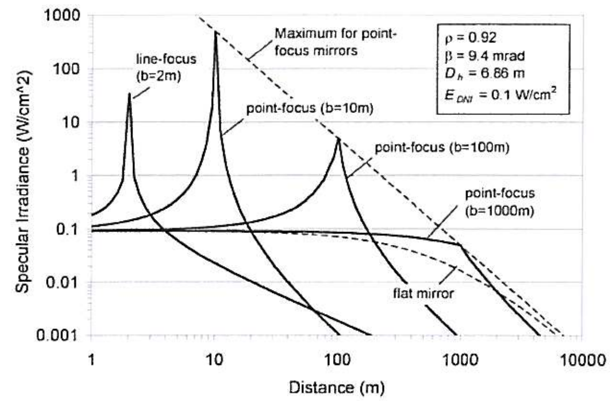

Fig. 5 Specular irradiance at the cornea as a function of distance from point-focus and line-focus mirrors with different focal lengths, *b*, for a solar irradiance of 0.1 W/cm²

point-focus mirror has been derived [1] with the following assumptions (see Fig. 4):

- uniform sun radiant intensity (no limb darkening)
- round, focused, continuous surface mirrors
- no cosine losses, off-axis aberrations, or atmospheric attenuation
- uniform irradiance in beam cross section.

The assumptions above will generally produce the largest beam irradiance, but the assumption of uniform sun radiant intensity averages the irradiance over the entire beam. Using a nonuniform solar intensity creates larger peak irradiances toward the center of the beam. Comparisons with a ray-tracing model (ASAP®) show that the difference in peak irradiance is about 25–30% at the focal length, but the difference can be greater at other distances.

The beam irradiance, E_{beam} (W/cm²), is then calculated as the product of the direct normal irradiance, E_{DNI} (W/cm²), the mirror reflectivity, ρ, and the area concentration ratio, C

$$E_{beam} = \rho E_{DNI} C \tag{6}$$

The direct normal irradiance, E_{DNI}, at the earth's surface is approximately 0.1 W/cm². The area concentration ratio, C, can be calculated as follows assuming a circular mirror area, A_h, with radius, R_h, and a circular beam area, A_x, with radius, R_x, at a distance, x, from the mirror,

$$C = \frac{A_h}{A_x} = \left(\frac{R_h}{R_x}\right)^2 \tag{7}$$

The radius, R_x, of the beam is comprised of two components,

$$R_x = R_1 + R_2 \tag{8}$$

where R_1 is caused by beam spreading due to the subtended angle of the sun and mirror contour inaccuracies (slope error), and R_2 represents the focusing and defocusing characteristics of the beam at a distance that is less than or greater than the focal length. The beam divergence, R_1, at a distance, x, from the mirror is defined by the sun half-angle (~4.7 mrad) and any additional slope errors caused by mirror inaccuracies,

$$R_1 \approx x \tan\left(\frac{\beta}{2}\right) \tag{9}$$

where $\beta/2$ is the half-angle (rad) of the total beam divergence. According to Ref. [1], this approximation has an error that is less than 0.3% for $b/R_h > 18$. R_2 can be defined using similar triangles as shown in Fig. 4, where b is the focal length,

$$\frac{R_2}{|x-b|} = \frac{R_h}{b} \Rightarrow R_2 = \left|\frac{x}{b} - 1\right| R_h \tag{10}$$

Using Eqs. (7)–(10) in Eq. (6), and the approximation that $\tan(\beta/2) = \beta/2$ when $\beta/2$ is small, yields the following expression for the beam irradiance (W/cm²):

$$E_{beam} = \rho E_{DNI} \left(\frac{x\beta}{D_h} + \left|\frac{x}{b} - 1\right|\right)^{-2} \text{(point-focus collectors)} \tag{11}$$

where $D_h = 2\ R_h$. The beam irradiance can also be presented in units of "suns" by dividing Eq. (11) by E_{DNI} (~0.1 W/cm²). The maximum beam irradiance occurs at the focal length, $x = b$. In addition, the beam irradiance from a flat mirror can be calculated by setting $b = \infty$ in Eq. (11). The specular beam irradiance for several focal lengths is plotted in Fig. 5 as a function of distance, x, from the mirror. The reflectivity, ρ, is assumed to be 0.92, and the total beam divergence angle, β, is assumed to be equal to 9.4 mrad. The effective diameter of the mirror, D_h, is calculated from the total reflective surface (37 m²) of each heliostat used at the National Solar Thermal Test Facility at Sandia National Laboratories in Albuquerque, NM,

$$D_h = \left(\frac{4A_h}{\pi}\right)^{0.5} \tag{12}$$

In addition to the beam irradiance, we also need to determine the size of the reflected sun image observed in the mirror to determine the subtended source angle and the retinal irradiance to assess potential ocular hazards in Fig. 2. It should be noted that the size of the reflected sun image in the mirror as viewed by an observer is different than the projected beam size calculated in Eqs. (8)–(10). An observer located within the projected beam and away from the focal point of a mirror may see a reflected image of the sun that occupies only a very small portion of the mirror. At the focal point, an observer would see a reflected image of the sun that fills the mirror.

As defined in Eq. (6), the beam irradiance is proportional to the concentration ratio, which is equal to the area ratio of the mirror and the beam size. It follows that the relative spot size of the reflected image of the sun in the mirror observed at a given distance, x, is proportional to the measured irradiance at that location. Then, once the beam irradiance, E_{beam}, is determined for the focused mirror using Eq. (11), the spot size of the reflected image of the sun observed in the focused mirror can be estimated relative to the equivalent spot size observed on an infinitely large flat mirror ($b \rightarrow \infty$, $D_h \rightarrow \infty$) at the same location,

$$\frac{A_{spot}}{A_{spot,flat}} = \left(\frac{d_{spot}}{d_{spot,flat}}\right)^2 = \left(\frac{x\omega_{spot}}{x\beta}\right)^2 = C = \frac{E_{beam}}{\rho E_{DNI}}$$
$$\Rightarrow \omega_{spot} = \beta\sqrt{\frac{E_{beam}}{\rho E_{DNI}}} \tag{13}$$

where A_{spot} is the area of the reflected spot image on a mirror as viewed by an observer a distance, x, away from the mirror, the subscript "flat" denotes a flat mirror that is sufficiently large so that the entire reflected image of the sun can be seen by the observer, d_{spot} is the diameter of the reflected image on the mirror, ω_{spot} is the subtended angle of the reflected sun image on the mirror as observed from a prescribed distance, and β is the beam divergence angle caused by the sun angle and slope error. For an infinitely large flat mirror, the diameter of the reflected sun image observed a distance, x, away from the flat mirror is approximately $x\beta$, and, according to Eq. (11), the beam irradiance is ρE_{DNI} as $b \to \infty$ and $D_h \to \infty$. Thus, if the measured irradiance, E_{beam}, is greater (or less) than ρE_{DNI}, the observed size and subtended angle, ω_{spot}, of the reflected spot image of the sun on the focused mirror will be greater (or less) than the size and subtended angle, β, of the reflected sun image on a large flat mirror at the same location. Equation (13) can be intuitively checked at two distances, $x \approx 0$ and $x = b$. At $x \approx 0$ (observer located immediately next to the mirror), Eq. (11) yields a beam irradiance, E_{beam}, equal to ρE_{DNI}, and Eq. (13) yields a subtended spot angle equal to β, which is expected at $x \approx 0$ (the mirror essentially appears flat to the observer, and the subtended angle of the reflected sun image is the same as looking at a reflection in a flat mirror). At $x = b$, Eqs. (11) and (13) yield a subtended angle, ω_{spot}, of the reflected sun image equal to D_h/b, which indicates that the reflected sun image will fill the entire collector when the observer is at the focal point, as expected.

Using Eq. (13) in Eqs. (1) and (2) yields the following expression for the retinal irradiance, where the corneal irradiance, E_c, is set equal to the beam irradiance, E_{beam}, used in Eqs. (11) and (13),

$$E_r = \frac{\rho E_{DNI} d_p^2 \tau}{f^2 \beta^2} \tag{14}$$

Note that the retinal irradiance in Eq. (14) does not depend on distance from the source (neglecting atmospheric attenuation). As distance increases, both the power entering the pupil and the retinal image area (which is proportional to the square of the subtended source angle) decrease at the same rate. Therefore, the retinal irradiance, which is equal to the power entering the pupil divided by the retinal image area, is independent of distance. The corneal irradiance, however, changes as a function of distance as given by Eq. (11).

The plots in Fig. 5 represent corneal irradiance values (at front of the eye) that could be experienced at different distances and for mirrors of different focal lengths but with prescribed reflectivity, beam divergence angle, and effective mirror size. Equations (11) and (12) can be used to determine the beam irradiance [E_{beam}, which is equivalent to E_c in Eq. (2)] for other mirror characteristics, and then Eqs. (1) and (2) can be used to determine the equivalent retinal irradiance for comparison against the safe retinal irradiance metrics in Fig. 2. For example, at a distance of 200 m, the irradiance from a mirror with a focal length of 100 m and with the prescribed optical characteristics is approximately 0.057 W/cm^2 according to Fig. 5 and Eq. (11). To convert this "corneal irradiance" to a retinal irradiance, Eqs. (1) and (2) are used where the subtended angle, ω, is taken from the subtended angle, ω_{spot}, calculated in Eq. (13) to be 7.4 mrad for $\rho = 0.92$, $E_{DNI} = 0.1$ W/cm^2, and $\beta = 9.4$ mrad. The retinal irradiance is then found to be 7.2 W/cm^2 with $d_p = 0.002$ m, $f = 0.017$ m, and $\tau = 0.5$ [Eq. (14) yields the same value]. According to Fig. 2, at a subtended source angle of 7.4 mrad, the calculated retinal irradiance of 7.2 W/cm^2 will not produce permanent eye damage. However, the calculated irradiance is sufficient to potentially cause a temporary after-image if one has to view directly at the source. The minimum distance to yield a low potential for after-image in this example is calculated to be $\sim$910 m using Eqs. (5), (11), and (13).

3.1.2 Line-Focus Collectors. The equations derived in Sec. 3.1.1 for determining the specular beam irradiance from point-focus collectors can be readily extended to line-focus (parabolic trough, linear Fresnel) collectors. The primary difference is that the concentration ratio in Eq. (7) is changed since the convergence/divergence of rays caused by the shape of the line-focus mirror is primarily in one dimension (rather than two),

$$C = \frac{A_h}{A_x} = \frac{R_h}{R_x} \tag{15}$$

The resulting irradiance from specular reflections from a line-focus collector then becomes

$$E_{beam} = \rho E_{DNI}\left(\frac{x\beta}{D_h} + \left|\frac{x}{b} - 1\right|\right)^{-1} \text{(line-focus collectors)} \tag{16}$$

Equation (16) is similar in form to Eq. (11) for point-focus collectors. However, the irradiance from line-focus collectors decreases less rapidly with the distance past the focal point. Figure 5 shows the specular irradiance from a line-focus collector as a function of distance with an assumed focal length of 2 m, an aperture of 6.86 m, and characteristics as shown in the plot.

The equation that was used to calculate the spot size of the reflected image for point-focus mirrors [Eq. (13)] can be used to describe an *effective* spot size of the reflected sun image in the line-focus mirror.[2] Then, using Eqs. (13) and (16) in Eqs. (1) and (2) yields the same expression for the retinal irradiance as Eq. (14) for point-focus collectors. The retinal irradiance is independent of distance (assuming no atmospheric attenuation) because the retinal image area decreases at the same rate as the irradiance (albeit at a slower rate for line-focus mirrors than for point-focus mirrors); therefore, the retinal irradiance (power entering the eye divided by the retinal image area) is constant.

For the characteristics of a line-focus (trough) collector shown in Fig. 5, the specular irradiance at a distance of 100 m is 1.87×10^{-3} W/cm^2 [Eq. (16)]. The corresponding subtended source angle is 1.34 mrad [Eq. (13)] and the retinal irradiance is 7.2 W/cm^2 [Eq. (14)]. According to Fig. 2 and Eq. (5), this retinal irradiance and subtended source angle will not yield permanent eye damage, but there is a potential for after-image effects if one were to view the specular reflection directly. For this example, the minimum distance to yield a low potential for after-image effects is $\sim$170 m using Eqs. (5), (13), and (16).

3.2 Analytical Model of Diffuse Reflections. In many cases, reflections from receivers, which are used to absorb the concentrated solar irradiance from heliostat, dish, and trough collector systems, can be modeled as diffuse rather than specular. Calculation of the irradiance at a location resulting from diffuse reflections depends on the total irradiance received by the reflecting source, reflectivity of the source, geometry, orientation, and distance to the source. For a diffuse source, we assume that the reflected diffuse radiance, L_d (W/m^2-sr), is uniform in all directions. The diffuse irradiance, E_d (W/m^2), received by an observer at a radial distance, r (m), from the source can be written as a function of the diffuse radiance as follows:

[2]The effective spot size assumes that the reflected sun image is circular. In reality, the shape of the reflected sun image as viewed by an observer will become elongated along the linear (long) axis of the collector with increasing distance.

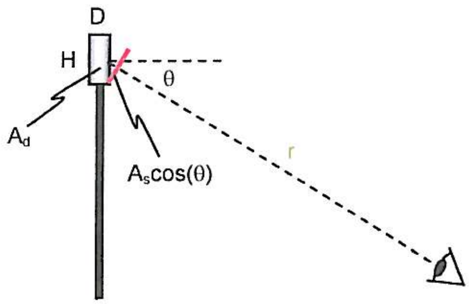

Fig. 6 Illustration of parameters used for diffuse-reflection calculations (e.g., viewing an external cylindrical receiver on top of a tower)

$$E_d = L_d \Omega \frac{A_s \cos(\theta)}{A_p} \tag{17}$$

where A_p is the pupil area (m^2), Ω is the solid angle (sr) subtended by the pupil of the eye as viewed from the source, A_s is the area of the source visible to the observer (m^2), and θ is the angle between the surface normal of the source and the line of sight between the source and the observer. The product of $A_s\cos(\theta)$ is the visible area projected toward the viewer (see Fig. 6) and is the area upon which the radiance, L_d, is based. Note that as θ increases to 90 deg, the visible source area and, hence, the diffuse irradiance goes to zero. Also, it should be noted that the visible source area, A_s, is not necessarily the same as the total area of the diffuse source, A_d. If the radiating source is planar then $A_d = A_s$. The potential for different areas of the diffuse source arise when a nonplanar source exists, such as a cylindrical external receiver. In this case, the diffuse source area, A_d, is equal to $\pi*D*H$, while the visible area, A_s, is approximately equal to $D*H$, where D is the diameter of the cylinder and H is the height. The projected area perpendicular to the line of sight is equal to $A_s\cos(\theta)$. See Fig. 6 for a graphical representation of these parameters.

In Eq. (17), the solid angle, Ω, subtended by the pupil area, A_p, as viewed from the diffuse source, can be expressed as follows:

$$\Omega = \frac{A_p}{r^2} \tag{18}$$

An expression for the radiance, L_d, in Eq. (17) can be derived by expressing the total reflected radiative flux, E_s (W/m^2), emitted into a hemisphere from an element of the diffuse source as a function of the radiance [15],

$$E_s = \int_0^{2\pi}\int_0^{\pi/2} L_d \cos\theta \sin\theta d\theta d\phi = \pi L_d \tag{19}$$

where θ and ϕ are the polar and azimuthal angles within a hemisphere over the emitting element. Assuming the reflection is uniform over all elements comprising the diffuse source, the total hemispherical radiative flux from a single element is also equal to the total reflected power emitted from the diffuse source, P_d (W), divided by the total surface area of the diffuse source, A_d (m^2),

$$E_s = \frac{P_d}{A_d} \tag{20}$$

Combining Eqs. (17)–(20) yields the following expression for the diffuse irradiance received at a distance, r, from the diffusely reflecting source,

$$E_d = \frac{P_d}{\pi A_d}\frac{A_s \cos(\theta)}{r^2} \tag{21}$$

where the total power emitted from the diffuse source, P_d, can be expressed as the product of the direct normal irradiance, diffuse source area, reflectivity of the diffuse source, and concentration ratio of the heliostat field to the diffuse source area,

$$P_d = E_{\mathrm{DNI}} A_d \rho_d C \tag{22}$$

Combining Eq. (21) with Eqs. (1) and (2) yields the following expressions for the subtended angle, ω (rad), and diffuse retinal irradiance, $E_{r,d}$ (W/m^2), where the corneal irradiance, E_c, is set equal to the diffuse irradiance, E_d, and the source size, d_s, is determined using Eq. (12) with $A_h = A_s\cos(\theta)$,

$$\omega = \frac{\sqrt{4A_s\cos(\theta)/\pi}}{r} \tag{23}$$

$$E_{r,d} = \frac{P_d d_p^2 \tau}{4A_d f^2} \tag{24}$$

As an example, the irradiance from a diffusely reflecting power-tower external cylindrical receiver is calculated using the following parameters:

- irradiance on power-tower receiver $= 1\times10^6$ W/m^2 (1000 suns at a DNI = 1000 W/m^2)
- radius of receiver = 10 m
- height of receiver = 20 m
- height of tower = 100 m
- receiver surface area = 1257 m^2 (calculated from receiver radius and height)
- reflectivity of receiver = 0.1 – 0.5.

Figure 7 shows a plot of the calculated corneal irradiance (at the front of the eye) as a function of distance from the receiver for reflectivity values of 0.1 and 0.5, assuming a diffuse radiance [Eq. (21)]. The irradiance decreases rapidly with increasing distance because the area over which the radiative power is distributed grows as a function of distance squared. Near the base of the tower at a radial distance close to 100 m (looking up at the receiver), the irradiance drops off to zero because the visible source area [modified by cos(θ) in Eq. (21)] goes to zero.

The calculated irradiance can then be used to calculate the retinal irradiance using Eqs. (1) and (2) for comparison against the safety metrics in Fig. 2. For example, at a radial distance of 300 m (horizontal distance of 283 m), the irradiance from Eq. (21) is 0.067 W/cm^2 at a reflectivity of 0.5. The visible area, A_s, of the receiver is 20 m × 20 m = 400 m^2, and cos(θ) = 283/300 = 0.94. So, the projected area perpendicular to the line of sight is 400 × 0.94 = 376 m^2, and the effective diameter of an equivalent circular area is given by Eq. (12) as 21.9 m. The subtended angle of the receiver is then calculated as 21.9 m/300 m = 0.073 rad, and the retinal image size is 1.24×10^{-3} m using $f = 0.017$ m.

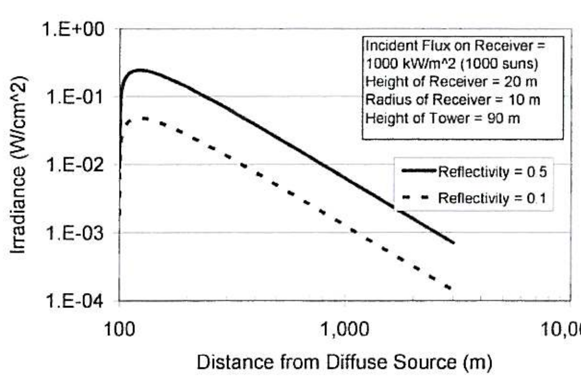

Fig. 7 Irradiance at the cornea as a function of distance from a diffuse source with different reflectivities

Equation (2) then yields a retinal irradiance of 0.087 W/cm^2 using $d_p = 0.002$ m [Eq. (24) yields the same value]. According to Fig. 2 (retinal irradiance = 0.087 W/cm^2 and subtended angle = 73 mrad), this irradiance will not cause irreversible eye damage, but it is sufficient to produce a temporary after-image if one looks directly at the source. The minimal safe distance to prevent a temporary after-image effect can be calculated by using Eqs. (5) and (23) to determine at what distance, r, the retinal irradiance (0.087 W/cm^2) is less than the after-image threshold given in Eq. (5). This distance is calculated to be approximately 1840 m, assuming no atmospheric attenuation. This large distance is a result of the large receiver size and the large amount of incident power on the receiver (1000 suns).

4 Testing and Model Validation

The specular and diffuse reflection models were evaluated via testing at the NSTTF at Sandia National Laboratories. Irradiances from specular reflections were evaluated by aiming a parabolic dish collector off-axis from the sun. Irradiances from diffuse reflections were evaluated from heliostat-generated beam images on the front wall of the central receiver tower at the NSTTF. A Nikon D70 digital single-lens reflex camera was used to capture the reflected images from the sun off both the parabolic dish and the tower wall at varying distances from the reflected image using f/32 and a shutter speed of 1/8000th second. Distances were recorded using a Bushnell Scout 1000 Rangefinder. Tiffen neutral density (ND) filters that are intended to reduce the intensity of all wavelengths of light equally, were applied to the camera lens to prevent the sunlight from saturating the image. The transmittance, T, of the ND filters is calculated as follows:

$$T = 10^{-\mathrm{OD}} \qquad (25)$$

where OD is the optical density of the filter. For example, an ND0.3 filter has an optical density of 0.3 and transmits 50% of the incoming light, while an ND0.9 filter has an optical density of 0.9 and transmits only 13% of the incoming light. Direct images of the sun, which were used as a reference for the reflected images, required several filters (three ND0.9 and an ND0.3), while images of the reflections required fewer filters.

MATLAB® was used to process the raw image files by summing the pixel intensity values over the region of the reflected sun image in each photo. Each pixel value was multiplied by the filter value(s) used in each image. For example, if a single ND0.3 filter was used, the pixel value would be multiplied by 2. The sum of the pixel values for each reflected image was divided by the sum of the pixel values for the direct sun image to yield the normalized irradiance measured in suns. These values were then compared to the predicted irradiances from the models for the specular and diffuse reflection tests.

Errors associated with the predicted and measured reflected irradiance include the following: (1) uncertainty in the measured reflectivity of the glare source, (2) uncertainty in the measured distance, (3) uncertainties associated with the camera detector and ND filters, and (4) uncertainty in the area (number of pixels) associated with the reflected image (glare source). The uncertainty of the measured reflectivity can be ±2–3% for the specular surface of the dish facets, depending on the location of the measurements on the mirror versus the location of the actual reflected sun image. The uncertainty in the measured reflectivity for the diffuse tower surface was larger and is discussed later. Because the reflectivity is not used in the photographic measurements, uncertainties in the reflectivity only affect the predicted irradiance values.

The uncertainty associated with the measured distance to the reflected image is ±1 m. At distances between the observer and the glare source on the order of 10 m and 100 m, the error in the predicted irradiance is approximately 20% and 1%, respectively. The distance is not used in the photographic measurements of the irradiance.

Errors associated with camera response are expected to be small. Ulmer et al. [16] provide error estimates for camera linearity, noise (dark current, readout), and spectral influences, which can be caused by a nonconstant filter transmission as a function of radiation wavelength. Each of these factors was estimated to cause an error of approximately ±0.5% for a single pixel value. Dark current values (pixel value when no irradiance exists on the CCD) were measured to be ~0.1% of the maximum pixel value for the camera used in this study. Errors in the transmittance values associated with the ND filters can cause errors in the calculated pixel values and, hence, irradiance values. Ideally, the same ND filters should be used to record images of both the reflected and actual sun images so that any errors in the ND filter transmittance values will cancel.

The errors associated with the image processing increase with distance from the reflected image because the area representing the reflected image (i.e., number of pixels selected to represent the glare source) becomes relatively more uncertain as the image size is reduced. This can add to the uncertainty of the relative irradiance determined from the image processing algorithm. We estimate that the uncertainty in the irradiance associated with image size is less than 2–3% since the pixel values corresponding to regions outside the reflected image will be small relative to the pixel values corresponding to regions within the reflected image. To reduce these errors, one can zoom in to fill the camera screen as much as possible with the reflected or actual sun images. When determining the corneal irradiance, the zoom (camera focal length) can be different between photos of the reflected and actual sun images since the cumulative power represented by all pixels comprising the reflected and actual sun images is used (as opposed to the power received by an individual pixel). However, if the subtended angle of the glare source is desired, the zoom should be held constant so that the subtended angle of the sun can be used to determine the subtended angle of the reflected image (assuming the camera focal length is constant). The camera settings that control how much light enters the iris (f-stop and shutter speed) should also be kept constant when comparing images between the reflected and actual sun images.

4.1 Specular Reflection Tests. The specular reflection tests were conducted on July 1, 2009, at approximately 9:30 AM (mountain daylight time (MDT)) with a direct normal irradiance of approximately 850 W/m^2. The Mod 2-2 10 kW parabolic dish used in the tests had a focal length of 5.448 m, a diameter of 8.8 m, a measured reflectivity of 0.93, and an estimated rms slope error of 1 mrad [17]. An rms slope error of 1 mrad results in a total beam divergence angle, β, of 11.4 mrad [9.4 mrad (from subtended sun angle) + 0.001 mrad*2 (pointing error)]. The dish was positioned so that the reflected image of the sun was visible on mirror facets of the dish as the observer moved in a southerly direction away from the dish. Photos of the reflected image on the dish were taken at varying distances, and the images were processed in MATLAB®. Results are shown in Fig. 8, along with the analytical predictions using Eq. (11) (where E_{beam} is divided by E_{DNI} to get the normalized irradiance).

A commercial ray-tracing code, ASAP®, was also used to model this system using the parameters described above, and the results are shown in Fig. 8. In the ray-tracing simulations, up to 20×10^6 rays were used to simulate the average irradiance on a small target located at different distances from the collector, representative of the observer (camera) locations in the test. The dish was modeled as an ideal paraboloidal collector with the dimensions and optical characteristics described above. A mirror random-roughness model corresponding to an rms slope error of 1 mrad [17] was used in the ray-tracing model. Apodization of the source rays was also included to account for sun shape and limb darkening [18].

The results show that the measured and predicted normalized irradiance from the specularly reflected image of the sun on the

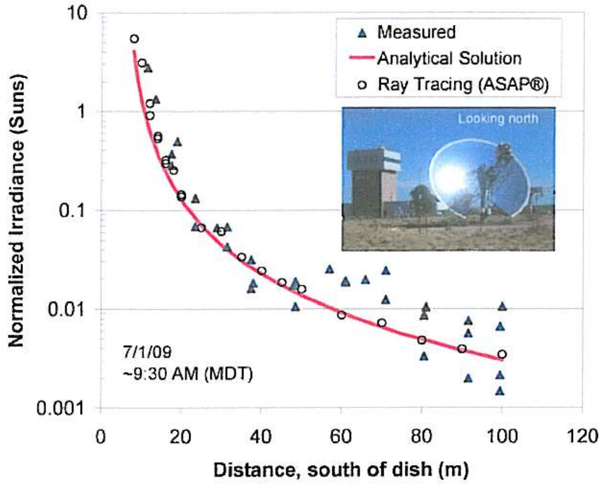

Fig. 8 Predicted and measured normalized irradiance as a function of distance caused by specular reflections from the Mod 2-2 10 kW parabolic dish

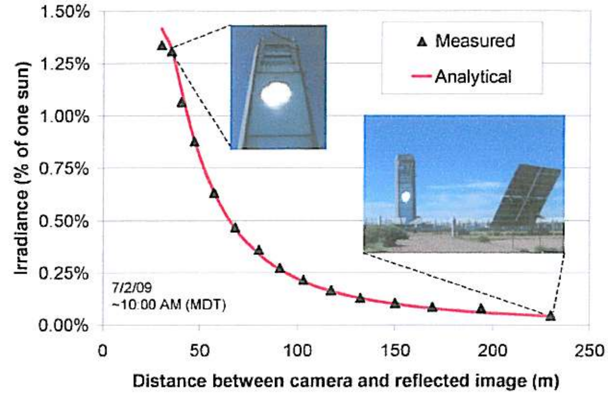

Fig. 9 Predicted and measured normalized irradiance as a function of distance caused by diffuse reflections from the NSTTF central receiver tower

dish facets match very well over the range of distances tested. At small distances (within two focal lengths), the normalized irradiance can exceed 1 sun. At greater distances, the normalized irradiances decrease rapidly due to the diverging beam. It is interesting to note that the analytical solution, which assumes a uniform sun intensity and neglects off-axis aberrations, matches extremely well with the ray-tracing solution, which rigorously includes these effects. This demonstrates that the analytical solution can be used to give good estimates of the average irradiance as a function of distance from the specular reflection, even with off-axis conditions.

The average irradiance, which represents the irradiance at the cornea at a particular distance, can then be used to determine the retinal irradiance for comparison against the safety metrics. For example, at a distance of 40 m, the normalized irradiance is approximately 0.02 suns. From Eq. (13), the subtended angle formed by the reflected image of the sun on the dish is calculated as 1.7 mrad, where $E_{\text{beam}}/E_{\text{DNI}}$ is the normalized irradiance of 0.02 suns, $\rho = 0.93$ and $\beta = 11.4$ mrad. Assuming a direct normal irradiance of 0.1 W/cm^2 (equal to one sun), the retinal irradiance is then calculated to be ~ 5 W/cm^2 using Eqs. (1) and (2) with $d_p = 0.002$ m, $f = 0.017$ m, and $\tau = 0.5$. According to Fig. 2, a retinal irradiance of 5 W/cm^2 with a subtended angle of 1.7 mrad is less than the safe retinal irradiance metrics to prevent permanent eye damage. However, the calculated irradiance is sufficient to potentially cause a temporary after-image if one were to view directly at the reflected image. Equations (5), (11), and (13) yield a minimal distance of 55 m for this system to yield a low potential for after-image effects.

4.2 Diffuse Reflection Tests. The diffuse reflection tests were conducted on July 2, 2009, at approximately 10:00 AM (MDT) with a direct normal irradiance of approximately 880 W/m^2. A 147 m^2 ATS heliostat with a reflectivity of ~ 0.9 was used to concentrate a beam of sunlight onto the front of the NSTTF central receiver tower that was painted white. The reflection of the sunlight from the front of the painted tower was approximately diffuse based on reflectivity measurements taken later with a Surface Optics, Inc. 410 Solar reflectometer. Reflectivity measurements ranged from ~ 0.4 (in pitted and soiled regions) to ~ 0.8. In all measurements, the diffuse component of the reflectivity was >99% of the total reflectivity. Photos of the beam on the tower were taken at varying distances from the tower, and the images were processed in MATLAB® to determine the normalized irradiance values. Analytical predictions of the irradiance as a function of distance were made using Eq. (21), where the diffuse power emanating from the tower is calculated as the total incident power on the tower times the reflectivity of the tower. The total incident power is calculated as the product of the DNI (880 W/m^2), the surface area of the heliostat (147 m^2), the reflectivity of the heliostat (0.9), and the cosine loss (0.78) due to the off-axis position of the heliostat (calculated at the date and time of the test), which yields 91 kW. The total diffusely reflected power, P_d, emitted from the front of the tower is equal to the incident power times the reflectivity of the white paint on the tower.

Figure 9 shows the results of the measured and predicted irradiances normalized to the DNI, assuming an average reflectivity of 0.7 for the white paint in the predicted values. Reflectivity measurements ranged from ~ 0.4 to ~ 0.8, with most of the measurements closer to 0.8. An average reflectivity value of 0.7 was used because it gave the best fit to the data. Results show that the measured and predicted irradiances match very closely and follow the same trend as a function of distance from the source. At close distances, both the predicted and measured irradiances show a slight decrease in the slope of the irradiance, which is caused by the reduced visible area of the reflected sun image at large viewing angles [cosine loss in Eq. (21)]. This demonstrates that the analytical solution can be used to estimate the irradiance as a function of distance from diffuse reflections.

5 Summary and Conclusions

This paper has presented methods to evaluate potential glint and glare hazards from specularly and diffusely reflected sunlight from concentrating solar collectors. First, a review of metrics was presented to determine safe retinal irradiances as a function of subtended source angle (or retinal image size). Metrics for both permanent eye damage and temporary after-image effects were included. Analytical models were then derived to calculate irradiances from both specular and diffuse sources. These models were validated using data collected from specular and diffuse reflection tests.

The methods and equations presented in this paper can be used to calculate irradiances from various concentrating solar collector systems (e.g., heliostats, dishes, troughs, receivers). The calculated retinal irradiance can be compared against the safe retinal irradiance metrics to evaluate potential glint and glare hazards. It should be noted, however, that the quantified metrics and estimates for retinal irradiance do not account for all factors. For example, atmospheric attenuation and the impact of wearing sunglasses are not considered in the models. In addition, human factors and behaviors are not assessed in this paper, which may affect the impact of different glint and glare scenarios.

The impact of multiple coincident beams (i.e., from adjacent collectors or receivers) was not considered in this study. Brumleve (pp. 27–32) [1] provides a discussion of the impact of multiple sources that can be used together with the results of this study. In general, multiple sources can increase the retinal image size. In addition, the retinal irradiance may or may not increase depending on whether the projected retinal images overlap, which depends on the positions of the sources relative to the observer. For example, if two beams enter the eye but do not overlap, the affected retinal image area is increased, but the irradiance (W/cm^2) is the same as that from a single beam. If the two beams are nearly coincident and form a coalesced image on the retina, the retinal image size is about the same but the irradiance increases.

Based on the configurations and operation of the various concentrating solar technologies, potential glint and glare scenarios that should be considered include the following:

- Power-towers
  - Specular reflections from heliostats when they are moving to or from stowed position, in standby mode, or not aimed at the receiver.
  - Diffuse reflections from the receiver.
- Linear collectors
  - Specular reflections from the mirrors when they are moving to or from stowed position and from specular reflections off the ends of the trough or mirrors when the sun is low and aligned with the mirrors (e.g., reflections from the north end of a north–south field when the sun is low in the southern horizon).
  - Diffuse and specular reflections from receiver tubes and bellows shields.
- Dish/engine systems
  - Specular reflections from mirror facets when the dish is off-axis (offset position) or moving to or from a stowed position.
  - Diffuse reflections from the receiver aperture.

Acknowledgment

The authors would like to thank Brian Myer, John Quintana, Kirill Trapeznikov, and Chuck Andraka for their assistance with the dish testing and MATLAB image processing. The authors also thank Siri Khalsa for his assistance compiling and interpreting the safety metrics.

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Nomenclature

A = area (m^2)
A_d = total area of diffuse source (m^2)
A_s = visible surface area (m^2)
b = focal length (m)
C = concentration ratio
d, D = diameter (m)
E = irradiance (W/m^2 or W/cm^2)
E_s = reflected radiative flux emitted from diffuse source (W/m^2)
f = eye focal length (~0.017 m)
L = radiance (W/m^2-sr)
ND = neutral density
OD = optical density of filter
P = power (W)
r = distance (m)
R_x = beam radius at distance x from the mirror (m)
R_1 = portion of beam radius caused by spreading due to subtended angle of the sun and mirror contour inaccuracies (slope error) (m)
R_2 = portion of beam radius caused by focusing and defocusing characteristics of the mirror (m)
rms = root mean square
T = transmittance
x = distance (m)

Subscripts

beam = specular beam of sunlight
burn = retinal burn threshold
c = cornea
d = diffuse
DNI = direct normal irradiance
flash = after-image or flash blindness threshold
flat = flat mirror
h = heliostat
p = pupil
r = retinal
s = source
spot = reflected sun image on mirror
x = distance (m)

Greek Symbols

β = beam divergence angle (rad)
φ = azimuthal angle in hemisphere (rad)
ρ = reflectivity
θ = angle between surface normal of the source and line of sight between the source and the observer; also the polar angle in a hemisphere (rad)
τ = ocular transmission coefficient (~0.5)
ω = subtended angle (rad)
Ω = Subtended solid angle (sr)

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Wendi Maez

From: kerry and jacque hart <hartline@GoJade.org>
Sent: Monday, January 23, 2012 12:28 PM
To: wmaez@saguachecounty-co.gov
Subject: letter of protest 3 (1-21-12).docx
Attachments: letter of protest 3 (1-21-12).docx

Wendi Maez,
Please accept this letter in protest to the Saguache Board of County Commissioners considering the Solar Reserve's permit 1041
Thank you,
Dr. Kerry Hart and
Jacqueline Hart

__________ Information from ESET NOD32 Antivirus, version of virus signature database 6820 (20120123) __________

The message was checked by ESET NOD32 Antivirus.

http://www.eset.com

Kerry and Jacque Hart

P.O. Box 1562
Alamosa, CO 81101

719-587-3342
hartline@GoJade.org

January 21, 2012

RE: Letter of Protest

Dear :

Please accept this correspondence as our official protest to the proposed implementation of solar towers by Saguache Solar Energy, LLC in the San Luis Valley. (a project-specific entity owned by SolarReserve, LLC, based in Delaware) The basis for this protest will explained in the narrative that follows.

Before we address the adverse impacts of the proposed tower and consequent transmission lines in the San Luis Valley, let us make it perfectly clear that we do not advocate blind opposition to progress; however, we are opposed to blind progress (i.e., blind in the sense when progress lacks thought, planning, and organization). And this "blind progress" is clearly the position Saguache Solar Energy has taken with the proposed solar tower.

There are a number of adverse direct impacts this proposal will have. The most salient are:

- A permanent compromise of an extended swath of virgin land across the San Luis Valley;
- Loss of use of private property along the path of the transmission line that will be a necessary consequence of the tower;
- Aesthetic impacts and loss of scenic values forever;
- Water quality impacts from herbicides used to maintain the tower and the line right-of-way;
- Loss of wildlife habitat and a threat to biodiversity (the San Luis Valley contains many natural wetlands and is home to endangered migratory birds – specifically the Sand Hill Cranes;
- Electrical interference with appliances near tower and the line;
- Compromise of historic designation

Indirect adverse impacts will stem from increased sales of power, and will include:

- Increased emissions of greenhouse gases for the life of the line (30-50 years+);
- Increased electricity costs to local customers who will pay a portion of the construction and operation costs. This is particularly egregious in light of the probability that power will be transported from outside the San Luis Valley, will burden the taxpayers of the San Luis Valley, but will benefit those in the metropolitan areas of the Front Range of Colorado since it will merely pass through the San Luis Valley – albeit it will pick up a miniscule of clean solar energy as it passes through;

We opine that part of the rush for Saguache Solar Energy to implement this project is based on the fact that the trend is to shift away from transmission lines and focus on local delivery systems. This new delivery system of energy, called "microgrids," are mini-islands of power fueled by distributed solar, wind and Combined Heat & Power (CHP) plants. For obvious reasons, utility companies such as Saguache Solar Energy are resistant to the concept of a microgrid which allow communities to rely on solar PV, small wind turbines, fuel cells, and CHP units when the larger grid goes down. Indeed, there are many experts who say that microgrids are the wave of the future and towers and transmission lines should be our last priority.

It would be in Saguache Solar Energy interest for longevity by the way energy companies operate, to construct expensive towers and transmission lines quickly before microgrids or some other form of delivering clean energy supplant the way Saguache Solar Energy and other energy companies currently do business. Indeed, Saguache Solar Energy poorly constructed proposal a towers and for transmission lines in the San Luis Valley is truly an impediment to progress.

The points of protest listed in this correspondence, while having foundation in opinions from experts (scientists and former employees of the coal and gas industries), are no doubt considered arguable by those in the energy industry who can profit from the towers and transmission lines across the San Luis Valley. Regardless of the differing opinions surrounding this issue, we can and must agree that the proposal for the towers and transmission lines cannot proceed until all the facts have been gathered and all relevant information carefully studied regarding the impact this will have not only on a section of pristine land that will be forever changed, but also for the adverse impact this will have on the environment in our global community.

To allow Saguache Solar Energy to proceed with their proposal without exercising due diligence would be reckless. We urge you to support an injunction of the towers and transmission line construction until the adverse impacts to the San Luis Valley can be thoroughly considered from every perspective.

Sincerely,

Dr. Kerry Hart
Jacqueline T. Hart

Wendi Maez

From: Debbie Westra <debbie.westra@gmail.com>
Sent: Thursday, January 26, 2012 2:29 PM
To: wmaez@saguachecounty-co.gov
Subject: please postpone approval of Solar Reserve Power Tower

Please postpone approval of the massive Solar Reserve Saguache Power Tower proposal until after the similar Crescent Dunes, NV project is up and running and more studies have been conducted on the actual impacts of this new technology.

We have time to do solar correctly. Let's do it wisely and get it right.

Regards,

Debbie Westra
PO Box 144
Villa Grove, CO 81155
phone: 655-2067

Wendi Maez

From: Sandra J Santa Cruz <ssantacruz@adams.edu>
Sent: Thursday, January 26, 2012 2:35 PM
To: wmaez@saguachecounty-co.gov
Subject: Solar Reserve Saguache Power Tower proposal

To Whom This Concerns:

Please postpone approval of the massive Solar Reserve Saguache Power Tower proposal until after the similar Crescent Dunes, NV project is up and running. IT IS IMPERATIVE THAT more studies are conducted on the actual impacts of this new technology.

Sandra J. Santa Cruz
Chama, CO 81126

Wendi Maez

From: tellentuck@gmail.com on behalf of Tamar Ellentuck <tamar@veteransgreenjobs.org>
Sent: Thursday, January 26, 2012 2:45 PM
To: Wendi Maes
Subject: Postpone Decision On Solar Reserve

Please postpone the decision on the Solar Reserve project until real data, from an operating facility, is available on the real impacts, negative and positive of this unproven technology.

Wendi Maez

From: H Nye <hnye@hotmail.com>
Sent: Thursday, January 26, 2012 2:58 PM
To: wmaez@saguachecounty-co.gov
Subject: Solar Towers

Saguache County Commissioners,
I have just seen the proposal for the twin towers and would like to add a protest over the building of them.
I also have the same concerns that you have on the impact on our valley. The loss of agriculture land and the view are only two of the things that could be a problem of these towers. The new jobs most likely not even be people from the area and would be just for a limited time as they build them.

I have spent a lot of time out of the valley and the best part on coming home is the beautiful view of the mountains and the stars at night. I feel with the building of the towers could start the decay of our views here so it would be just like the cities I have lived in for months at a time and there is nothing better than to come home to the view here in the valley.
Thank you,
Holly Nye
2588 County Rd 49
Center, CO 81125
719-588-2251

Wendi Maez

From: Jenny Nehring <jennynehring@hotmail.com>
Sent: Thursday, January 26, 2012 2:58 PM
To: wmaez@saguachecounty-co.gov
Subject: Solar Reserve Comment

Dear Saguache County Commissioners:
I would like to comment on the proposed Solar Reserve energy proposal. I am a wildlife biologist who specializes in avian projects. I have lived and worked in the Valley for 14 years.
The 2011 Spring Avian and Crane Survey and report by Tetra Tech for the Solar Reserve Project is flawed and does not adequately reflect the avian community of the project area.

- The most glaring problem with the 2011 Spring Avian and Crane Survey is that surveys were not conducted at different times of year or throughout the year. Birds utilize habitat in different ways depending on seasons. This is especially true for cranes and especially true for cranes in the SLV. In the spring, cranes concentrate near the Monte Vista NWR where food and roosting habitat are provided in the form of flooded wetlands and grain fields on the refuge left unharvested in the fall are available to cranes in the spring. During fall migration cranes are much more widely dispersed across the valley because food in the form of residual grain after harvest and water, shallow wetlands needed for roosting are more available across the Valley floor. Extrapolating crane use of an area based on spring surveys alone grossly underestimates crane populations and use of an area.
- Secondly, the period in which the point count surveys were conducted are inadequate to measure breeding birds. The report states that surveys were conducted until May 30 to include early summer breeding. Anyone who has lived in the SLV knows that May 30 does not constitute early summer. Only year round resident species of birds are in breeding mode by that time. The breeding season is barely beginning for migrant species at that point. Because surveys were not conducted in to June several species of breeding birds have been excluded from the data or their numbers are not adequately represented.
- Finally when 73 out of 540 birds (13.5%) are listed as unidentified in a bird survey you must question the expertise of those conducting the surveys. The floor of the SLV is not a super abundant or diverse habitat for birds, being unable to identify approximately 3 out of every 20 birds makes for a very poor survey.

I would like to close requesting that a more complete avian survey of the project area be completed so that impact to birds is better understood. Also, I believe it is prudent to postpone approval of the massive Solar Reserve Saguache Power Tower proposal until after the similar Crescent Dunes, NV project is up and running and more studies have been conducted on the actual impacts of this new technology.

Thank you for your consideration.

Jenny Nehring
Wildlife Biologist
Nehring Consulting
416 Adams St.
Monte Vista, CO 81144
719-480-0872
jennynehring@hotmail.com

Wendi Maez

From:	SeEtta Moss <seettam@gmail.com>
Sent:	Thursday, January 26, 2012 3:00 PM
To:	wmaez@saguachecounty-co.gov
Subject:	Solar Reserve permit request
Attachments:	SaguacheCounty.doc

Please accept the attached comments from the Arkansas Valley Audubon Society regarding the 1041 permit request by Solar Reserve. Thank you

SeEtta Moss, Conservation Chair

__________ Information from ESET NOD32 Antivirus, version of virus signature database 6830 (20120126) __________

The message was checked by ESET NOD32 Antivirus.

http://www.eset.com

Arkansas Valley Audubon Society
www.SoCoBirds.org
AVAS exists to promote the conservation of nature through education, political action and field activities. Our focus is on birds, other wildlife, and their habitat in Southern Colorado.

SeEtta Moss
Conservation Chairperson
725 Frankie Lane
Canon City, CO 81212
January 26, 2012

Saguache County Commissioners
Saguache County Land Use Dept.
P.O. Box 326
Saguache, Colorado 81149

REF: 1041 Application by Solar Reserve

Dear Board of County Commissioners:

Please accept these comments from the Arkansas Valley Audubon Society which is the local chapter of the National Audubon Society which represents approximately 500 members who live in the San Luis Valley as well as parts of So. Central and southeast Colorado. Arkansas Valley Audubon Society is a proud supporter of the Sand Dunes National Park and the Baca National Wildlife Refuge, both of which are located predominately in Saguache County. Many of our membership have recreated in your county as they engage in bird and wildlife watching. I would add a personal note that I have visited Saguache County on many occasions to not only watch birds and the other wonderful wildlife resources in your county but to conduct wildlife surveys. Like many others who are bird and wildlife tourists I have stayed in lodging in the Crestone area, visited the Alligator Farm on several occastions and purchased food in several locations in your county.

Conservation and enhancement of natural resources including birds, bats and other wildlife pay off for local areas. The Department of the Interior's report, *2006 National Survey of Fishing, Hunting and Wildlife-related Recreation,* found that in 23 million persons engaged in watching wildlife *away from home* in 2006--this is the number that not only watches birds and wildlife at home but travels away from home to do so. They spent $12.9 Billion on trip related expenses. There are additional economic impacts from hunting. I point this out as I have serious concerns about the potential for serious negative impacts on the birds, other wildlife and their habitat from the industrial scale solar projects proposed by Solar Reserve. I certainly understand that Saguach County is interested in the economic value that Solar Reserve states it has the potential to provide to the county. However, if that project damaged the natural resources in Saguache County the long term economic interests of Saguache County residents could significantly reduce or even negate any economic value of locating this industrial project there.

I have reviewed the December 9, 2011 written comments from Colorado Parks and Wildlife that was available on your county website. I was unable to find the comments from the United States Fish and Wildlife Service that I understand were also submitted and which also outlined serious concerns about the impacts from the proposed Solar Reserve industrial project. The Arkansas Valley Audubon Society supports the concerns raised by Colorado Parks and Wildlife as well as their recommendations. We especially support their recommendation that if Saguache County decides to provide a permit for this industrial project that the 1041 permit **requires** that Solar Reserve implement an avian protection plan and that it be accomplished and approved by the professionals in the Colorado Parks and Wildlife Department as well as the United States Fish and Wildlife Service.

I would like to add an additional concern about the potential for serious deaths from the tall receiver towers and any supporting tall structures/guy wires to migrating birds during poor weather conditions. It has been found in a number of other projects that the lights on tall lighted towers can attract large numbers of migrating birds that becomed disoriented in adverse weather conditions, often circling the towers endlessly. Some of the birds collide with the towers and guide wires while others exhaust themselves. If you approve this project even with the potential for serious deleterious impacts on birds and resultant negative impacts on the wildlife related economic values in Saguache County, it is vital that this be given proper monitoring and definitely not just chosing 3 or so days in a year to monitor.

In conclusion, Arkansas Valley Audubon Society has serious concerns about the impacts that the Solar Reserve industrial-scale solar project will have on the currently excellent wildlife resources in Saguache County. There are so many potential issues that can result in serious injury, death and other consequences for the birds and wildlife that use migrate through and use this area that we would be most supportive of a denial of a 2041 permit for this project by the Saguache Board of County Commissioners.

Sincerely,

SeEtta Moss, M.S.
Conservation Chairperson

Wendi Maez

From: bruce polak <lesheures@yahoo.com>
Sent: Thursday, January 26, 2012 2:08 PM
To: WMAEZ@Saguachecounty-Co.Gov
Subject: solar tower miles from the sand

Dear Madame and sirs:
I have just read a flyer slandering yet another project involving this valley's ability to provide for its own needs..renewable energy needs.

Its seems you have a group of not in my back-yard ers who propagate utter and total nonsense and get people emotionally involved rather than looking at the facts! Where do these folks get their power now? Do they even know ? And where will their kids get theirs? They state that the power will be "shipped else where"...idiots! The grid is called the grid because supplies and users are all hooked together...grid !

"It would kill sandhill cranes and bald eagles....and raise power prices throughout the state"
What?
Are these folks crazy ? I think the birds have more sense than these folks who are obviously promoting their 'solar gardens'...how quaint.(Do they know any one who lives with only solar for their power? Have they heard stories that 5 years down the line all the batteries took a crap and they did not have enough spare dollars to replace them?) Just drumming up business for their own private agendas I would speculate.

Please do not let these uninformed and propagandizing idiots kill yet another project that would insure future generations from having CLEAN and RENEWABLE power for their homes.There may be problems..and all are addressable.Clearly there is not the negative impacts so falsely claimed.
I would ask..how many of these folks have power coming into their houses...and where do they think it comes from ? Most likely a coal fired plant..maybe a Nuke...and just because they are not having to look at it...folks like them are being effected(neg) by the process- perhaps hundreds of miles away.This project would replace that future new coal fired plant.No fuel costs...no fallout...a bit of maintanance and local jobs provided not to mention income for the county(tax).
I fail to understand the small mindedness of some of the residents in the beautiful valley...No foresight..only self interest,it seems.
I would like to speak with them one on one...or many,and find out where they get these outlandish ideas and why they cannot understand some basic facts.

Please inform me as to when that might be possible.

All Best,
Bruce Polak
B.P.Solar Tech

Ps.I notice that whoever is spreading these distorted opinions does not sign their name?...cowards as well as perjurers and fabulists.(my opinion). I hope it is not the "Fried Crane.org" folks.I have sent that link to quite a few informed scientists working in the field who have had some entertainment at the ridiculousness of their claims...

Wendi Maez

From: Nikole Kadel <nk@alexsaconsulting.com>
Sent: Thursday, January 26, 2012 2:16 PM
To: wmaez@saguachecounty-co.gov
Subject: Postpone Solar Reserve Saguache Power Tower proposal

Hello,

Please postpone approval of the massive Solar Reserve Saguache Power Tower proposal until after the similar Crescent Dunes, NV project is up and running and more studies have been conducted on the actual impacts of this new technology.

With gratitude,
Nikole

--

Nikole Kadel
D 415.308.3894 | f 866-575-3490
nk@alexsaconsulting.com

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Wendi Maez

From: Andrea Guajardo <andieguajardo@gmail.com>
Sent: Thursday, January 26, 2012 2:14 PM
To: wmaez@saguachecounty-co.gov
Cc: Ceal Smith
Subject: Solar Reserve

Please postpone approval of the massive Solar Reserve Saguache Power Tower proposal until after the similar Crescent Dunes, NV project is up and running and more studies have been conducted on the actual impacts of this new technology.

--
Andrea Guajardo, Executive Director
Conejos County Clean Water, Inc.
P.O. Box 153
Antonito, CO 81120
www.conejoscountycleanwater.org

Wendi Maez

From: Jillian Klarl Ellzey <jillian@northern-valley.com>
Sent: Thursday, January 26, 2012 2:26 PM
To: wmaez@saguachecounty-co.gov
Subject: Solar Project

Dear Wendi,

Please postpone approval of the massive Solar Reserve Saguache Power Tower proposal until after the similar Crescent Dunes, NV project is up and running and more studies have been conducted on the actual impacts of this new technology.

Thank you,

Jillian

--
Jillian Klarl Ellzey
PO Box 72
Crestone, CO 81131
719.588.5115