Speaker # 4
Kathy Pritchard

Desert Claim Docket # 18105

April 11, 2018

Kathleen Drew, Chair

Mr. Stephen Posner

EFSEC

Desert Claim Public Hearing

Ellensburg, WA

Dear Chair Drew & Mr. Posner:

Please accept these comments and the following documents into the public record for Desert Claim's amendment Docket #18105.

RCW 80.50 spells out the legislative policy and intent for the need to balance increasing energy demand with the broad interest of the public.

Yet the picture for energy supply and demand picture has changed dramatically since this legislation empowered EFSEC and more importantly since Desert Claim was approved in 2010.

According to the NW Power and Conservation Council the demand for energy has been flat in the Northwest for the last few years and will remain so in the immediate future.

Not only is the demand flat in the Northwest, demand is flat in California. Since 2010 the surge in California's energy production due to industrial and rooftop solar has changed energy markets. California is giving away excess energy to neighboring states in the West. In part, because PSE joined California's Energy Imbalance Market recently, the amount of energy available in the Northwest is abundant. Our energy supply will increase again this year with a new industrial solar project near Spokane; in 2019 Tri-Cities Hanford solar and wind in Thurston and Lewis Counties will all add to this supply.

With so many new industrial-size renewable projects, our state may experience California's problem: congestion. Congestion in transmission lines. Too much energy has California giving away electricity, but their ratepayers and taxpayers still pay for. Industrial producers say they will turn off solar panels, if the state pays for it.

What will excess supply do to existing power companies, like Kittitas Valley Wind, who at times are left searching for customers? What will this do to homeowners in our state who want to install solar on their roofs? The Department of Commerce's 2017 Biennial Energy report says that rooftop solar has increased so greatly that most state utilities have exceeded the cap for new connections. "Many utilities are no longer required to offer net metering to customers who install renewable energy systems," according to the report. Locally, we see this with the Kittitas PUD not accepting new connections into their system.

Into a market of oversupply and flat demand, you are being asked to consider an amendment with major changes. Changes in locations and size of turbines are beyond the scope of a simple amendment. The effects will be far-reaching: 31 turbines the height of the Space Needle will hinder Ellensburg's award-winning tourism program and the new state Tourism program which rely on natural vistas to attract visitors. Homeowners and small businesses may have rooftop solar links canceled if large utilities find there is no room on the grid for net metering. In addition, environmental impacts include harm to threatened species, e.g. eagles and bats, and water supply.

I respectfully submit the amendment be denied due to negative impacts to broad interests of residents and no evidence of pressing need for energy supply.

Best regards,

Kathi Pritchard

Ellensburg, WA

Attachments:

1)NW Forecast for Electricity Demand Growth is Flat, Steve Simmons NW Council.org

2)2017 Biennial Energy Report and State Energy Strategy Update, page 27-30

3) LA Times, California Invested in Solar: 2017 series: Ivan Penn, NY Times: "No. 1 Power Source Faces Headwinds" 3/28/18, Ivan Penn

4) Kittitas PUD "Distributed Generation", webpage

5) NREL Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment, January 2016

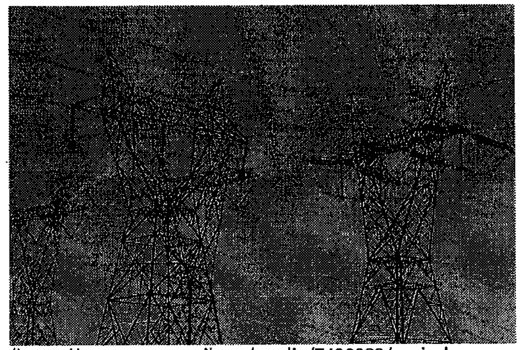
6) EFSEC: July 2017 Wild Horse Wind Facility: Eagle take permit report

NORTHWEST FORECAST FOR ELECTRICITY DEMAND GROWTH IS FLAT

But what about other regions?

Although our focus at the Council (http://www.nwcouncil.org/) is on the medium and long-term outlook for electricity demand in the Northwest, it's useful to check in to see what our neighboring regions are expecting and to gain insight into the forces that can recast forecasts over time.

Forecasting is not an exact science – as Nils Bohr or possibly even Yogi Berra may have said – "prediction is difficult, especially about the future." But we continue to plan for the future anyway.



(https://www.nwcouncil.org/media/7490932/c-windows-temp-unsplash-electricity-20170124113741.jpg)

Demand forecasting plays a key role in formulating power plans and strategies. For instance, planners forecasting electricity demand can help determine whether new power plants are required and when developers should build them. It can also help decide the type of power source: a low variable cost renewable source like solar or wind; a super-efficient gas-fired combined cycle combustion turbine that runs constantly; or a flexible natural gas unit like a reciprocating engine.

Changes to electricity demand forecasts generally reflect shifts in expectations of

- ▶ Economic growth
- ▶ Savings from energy conservation
- ▶ Consumer preferences and behaviors

Here in the Northwest, despite predictions of economic and population growth, we expect the long-term growth in demand for electricity to be flat (http://www.nwcouncil.org/news/blog/state-of-northwest-utilities-in-2015-december-2016/). This is due to our region's strong focus on energy efficiency (http://www.nwcouncil.org/news/blog/ee-baseline/). But what about other regions, especially our neighbors to the north and south? What sort of changes are they seeing in regard to forecasts for electricity?

Up north in the energy-rich Canadian Province of Alberta, demand forecasts can swing based on the fate of oil sands development – the extraction and refinement of oil from the sand, clay, and bitumen of the Athabasca region. Oil sand development directly drives electricity demand since the extraction and production of oil is very energy and water intensive. Greater oil sands development in response to high world oil prices also drives economic growth, which in turns adds to even more electricity demand. However, with the recent worldwide oil glut and low prices, oil sands development has cooled, lowering electricity demand forecasts. But conditions (and forecasts (https://www.aeso.ca/grid/forecasting/)) can change.

In California, different drivers are bringing changes to the electricity forecast. According to the California Energy Commission (http://www.energy.ca.gov/), growth in demand is leveling off in the Golden State. Once the effects from future energy efficiency and rooftop solar generation are factored in, its long-term forecasts for electricity demand are flat. Continued growth in rooftop solar installations by homeowners and businesses could significantly alter the dynamics of utility-served electricity load in the state.

For instance, in the middle of the afternoon, rooftop solar generation could greatly reduce the amount of electricity required from large, centralized power stations. But, in the evening as the sun sets and solar self-generation drops off, the system will need a flexible, quick reacting power source to respond to demand.

Natural gas power plants and demand response programs can provide flexibility, but in the future, the system may also use batteries (https://www.nytimes.com/2017/01/30/business/energy-environment/battery-storage-tesla-california.html?module=WatchingPortal&region=c-column-middle-span-region&pgType=Homepage&action=click&mediaId=thumb_square&state=standard&contentPlacement=8&version=internal&contentCollection=www.nytimes.com&environment%2Fbattery-storage-tesla-california.html&eventName=Watching-article-click) to store electricity generated during the day for use in the evening to help with this issue. Another factor we are keeping our eyes on for California is the rapidly growing popularity of electric cars, which will increase demand for electricity, and drop demand for gasoline (and therefore oil).

So, speaking of oil and cars, and possibly even the science of forecasting itself, we leave with a quote from another scientist and philosopher – Tom Magliozzi of Car Talk fame – "it's better to travel in hope than arrive in despair."

Tags: electricity demand forecast

Department of Commerce

2017 Biennial Energy Report and State Energy Strategy Update

Issues, Analysis & Updates

December 2016
Report to the Legislature
Brian Bonlender, Director

Acknowledgements

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Distributed Energy

Interconnection Standards

Since 2015, Commerce and its non-profit, utility, and city partners in both Oregon and Washington established the Northwest Solar Communities[28] program. The U.S. Department of Energy, along with local matching funds, underwrote the creation of the program. Northwest Solar Communities included activities related to streamlining and improving both distributed system interconnection and system permitting. The interconnection products included a best practices guide and interactive web site, new standard forms for faster and easier interconnection and several webinars on permitting.[29] These tools and information have been important elements in supporting the rapid increase in distributed energy resources especially residential and small commercial photovoltaic systems.

Commerce received an additional grant from the U.S. Department of Energy in October 2016 to continue its work with Washington and Oregon partners on the development and expansion of solar installation in the region. The new grant will focus on assisting the development of community solar systems, helping low and moderate income individuals install systems, and further investigate the value propositions available from solar deployment.[30]

Net Metering Policies

Net metering is the compensation arrangement between a utility and a customer with an on-site generation system, typically a solar photovoltaic system. Net metering gives the customer credit for power generation at the utility's retail rate and allows a customer to bank generation during hours or months when it exceeds the customer's consumption. Without net metering, a utility might offer a lower rate for electricity that flows back into the grid when generation exceeds consumption.

Net metering policies are set by each utility, subject to limitations set in state law (RCW 80.60). The law requires that utilities offer net metering, but they are not required to offer net metering to systems that exceed 100 kW in size. The obligation to offer net metering does not apply to additional systems after the cumulative capacity of all net metered systems exceeds 0.5 percent of the utility's peak demand in 1996.

The limitations of the net metering requirement are often misunderstood. They do not prohibit a utility from offering net metering to larger systems or offering net metering above the cumulative cap. The law also does not prohibit a utility from charging a fee to net-metered

[28] nwsolarcommunities.org
[29] nwsolarcommunities.org/priorities/interconnection
[30] Solar Plus Regional Initiative Wins $2 million Grant from U.S. Department of Energy

customers, but any special fee has to be justified based on identified costs and policy considerations.

The 2012 Washington State Energy Strategy concluded that Washington's net metering law is well-designed, and identified three potential improvements. These would expand the maximum size of individual systems and the cumulative capacity of systems that must be offered net metering. The third policy change was to expand the energy banking provision to allow carry over from year to year.

There have been no statutory changes to the net metering law since the 2012 strategy, though legislators have introduced bills to do so every year. Nonetheless, utilities have experienced a sharp increase in the number of solar photovoltaic systems installed under net-metering arrangements. In 2012, no utility was at or near its 0.5 percent net metering threshold. In 2016, most Washington customers are served by utilities that exceed the cumulative threshold. While many utilities are no longer required to offer net metering to customers who install new renewable energy systems, no Washington utility has withdrawn its net metering offer.

Other states have greater penetration of solar photovoltaic systems on their utility grids, and stakeholders there are debating and litigating a variety of changes to compensation and interconnection arrangements. Similar discussions occur in Washington and are likely to be guided by the experience of other states.

Streamlined Permitting for Distributed Energy

Commerce and the Oregon Department of Energy received funding for the U.S. Department of Energy's Rooftop Solar Challenge program to help reduce the "soft costs" of installation of rooftop solar systems. The funding led to the creation of the Northwest Solar Communities coalition made up for local jurisdictions, utilities, industry partners, and citizens groups. One of the major focus areas of the group is the "streamlining and standardization of the permitting processes and interconnection standards."

The Northwest Solar Communities initiative wrapped up its work on reducing "soft costs" of rooftop solar with a major advance. The State Building Code Council unanimously approved a change proposed by a coalition of Northwest Solar Communities to expedite permitting of standard solar photovoltaic systems without an engineer's stamp. While many jurisdictions already follow this routine, the code brings all jurisdictions into alignment. Engineering costs range from $500 to $2500 or more, and can add up to eight weeks for a solar installation. Partners also implemented solar group purchase programs in seven new communities. In just two and a half years, the installed solar capacity in Washington has quintupled, while costs have fallen almost 50 percent.

The U.S. Department of Energy funds and continues to support six Wind Energy Regional Resource Centers. The Northwest Wind Resource and Action Center, operated by Renewable Northwest with involvement from Commerce, worked with the Distributed Wind Energy

Association and Northwest SEED to develop model zoning and permitting practices for small-scale distributed wind systems, creating state-specific toolkits. The Permitting Toolkit for Washington is available from the Northwest Wind Resource and Action Center website.[31]

Distributed Energy in I-937

The 2012 Washington State Energy Strategy identified a number of policy and legislative changes that should be made to reduce obstacles to greater use of distributed energy. Washington has implemented all of these changes through legislation, administrative rule amendments, and agency policy.

Commerce used its rulemaking authority to provide the needed clarification of how the savings from combined and power projects should be counted and the 5 MW limit should be applied for distributed energy systems seeking to qualify for double credit.

The most important change since the 2012 strategy was to establish a process for utilities and project developers to obtain confirmation that a renewable energy project or conservation resource is eligible for credit under the EIA. The Legislature in 2012 authorized Commerce to issue advisory opinions on resource eligibility.

Using this authority, Commerce has addressed numerous complex issues that were unclear in the statute itself. The process also allows developers to obtain routine approvals that may be required by financial backers, and it has enabled the regional renewable energy tracking system to identify projects as Washington-eligible.

Rationalize Distributed Energy Incentives

The 2012 Washington State Energy Strategy identified nine different tax incentive provisions affecting distributed energy systems and recommended a comprehensive review of their purpose and effect. The strategy identified three preferences as priorities.

- Retail sales and use tax remittance for renewable energy production equipment (RCW 82.08.962). This tax preference was scheduled to expire in 2013, and the Legislature extended it to January 1, 2020.
- Property tax exemption for biodigesters (RCW 82.29A.135). The Legislature did not extend this exemption, which expired on December 21, 2012.
- Public utility tax credit for consumer produced power (renewable energy systems) (RCW 82.16.130). This tax preference expires on June 30, 2020. However, because it applies as electricity is generated instead of as a one-time credit, the effective amount of the

[31] nwwindcenter.org/sites/default/files/windpermittoolkit_wa_sept-2015v2.pdf

credit diminishes each year. The Legislature has not modified or extended this tax preference.[32]

The taxpayer cost of the renewable energy production credit has increased dramatically since 2012 as the number and size of solar photovoltaic systems has increased. This was particularly pronounced in 2014 and 2015, when the price of solar equipment decreased significantly and the incentive rates established in statute yielded high financial paybacks on new systems. The most recent projection is that the incentive will cost taxpayers $55 million during the 2017-2019 budget period. Most of the cost is due to incentives to encourage use of Washington-manufactured equipment rather than to encourage generation of renewable energy.

Growth in taxpayer cost is expected to slow as a result of the caps established in the statute. However, the caps have also raised concerns because some utilities have chosen to reduce incentive payments to existing system owners as new systems were added.

Stakeholders in the solar industry have proposed legislation to extend and reform the incentive program in every legislative session since 2013. Most states are reducing their solar incentives as system costs are decreasing. Any extension of the Washington program should provide significantly lower incentive levels and better controls to protect against unreasonably high payments to project owners.

Carbon Pricing

Executive Order 14-04 created a Carbon Emissions Reduction Task Force (CERT) made up of 21 leaders from business, labor, health, and public interest organizations. The charter of CERT was to provide the Governor with recommendations on the design and implementation of a market-based carbon pollution program. The CERT provided a final report to the Governor in November 2014. [33] The report produced four findings related to the creation of emissions-based or price-based market mechanisms for greenhouse gas reductions.

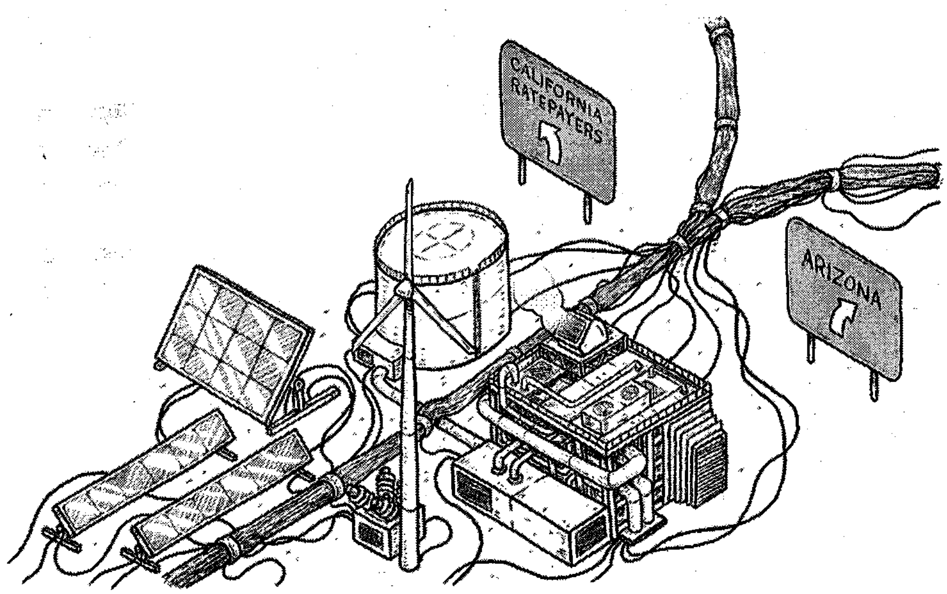
- Emissions-based or price-based market mechanisms add unique features to an overall carbon emissions reduction policy framework.
- Thoughtful and informed policy design, drawing on the lessons learned from other jurisdictions, CERT member perspectives, and additional analysis (see Finding 4), will be required to achieve either an emissions-based or price-based policy approach that is workable for the State of Washington.
- Reaching the State's statutory carbon emissions limits will require a harmonized, comprehensive policy approach.

[32] In addition to these priority items, the Legislature also extended until 2017 a reduction in the business tax on manufacture of solar energy equipment and components and expanded it to cover manufacture of solar grade silicon (RCW 82.04.294).
[33] www.governor.wa.gov/sites/default/files/documents/CERT_Final_Report.pdf

California invested heavily in solar power. Now there's so much that other states are sometimes paid to take it

By Ivan Penn

June 22, 2017



On 14 days during March, Arizona utilities got a gift from California: free solar power.

Well, actually better than free. California produced so much solar power on those days that it paid Arizona to take excess electricity its residents weren't using to avoid overloading its own power lines.

It happened on eight days in January and nine in February as well. All told, those transactions helped save Arizona electricity customers millions of dollars this year, though grid operators declined to say exactly how much. And California also has paid other states to take power.

The number of days that California dumped its unused solar electricity would have been even higher if the state hadn't ordered some solar plants to reduce production — even as natural gas power plants, which contribute to greenhouse gas emissions, continued generating electricity.

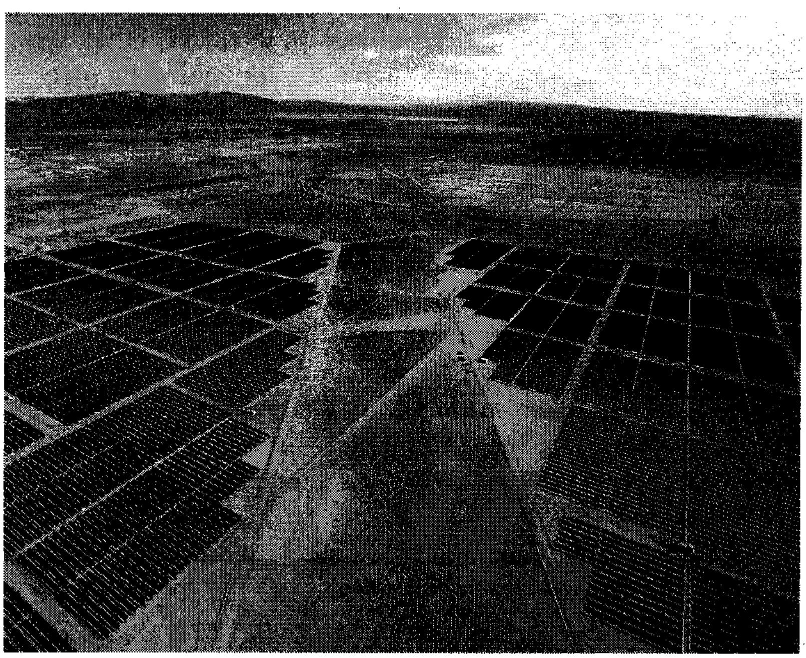
Solar and wind power production was curtailed a relatively small amount — about 3% in the first quarter of 2017 — but that's more than double the same period last year. And the surge in solar power could push the number even higher in the future.

Why doesn't California, a champion of renewable energy, use all the solar power it can generate?

The answer, in part, is that the state has achieved dramatic success in increasing renewable energy production in recent years. But it also reflects sharp conflicts among major energy players in the state over the best way to weave these new electricity sources into a system still dominated by fossil-fuel-generated power.

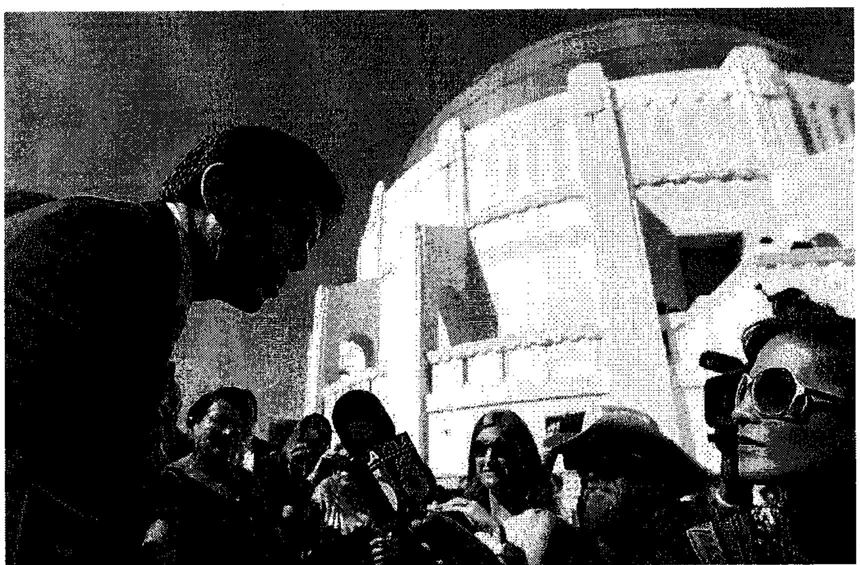
In Western Kern County, solar panels on almost two square miles of land form the Beacon Solar Project, owned by the Los Angeles Department of Water and Power. (Mel Melcon/Los Angels Times) City officials and builders in Redondo Beach want a mixed-use development to replace the current natural gas facility. They say there is no need to overhaul the power plant when there is an abundance of clean alternatives. (Rick Loomis/Los Angeles Times)

No single entity is in charge of energy policy in California. This has led to a two-track approach that has created an ever-increasing glut of power and is proving costly for electricity users. Rates have risen faster here than in the rest of the U.S., and Californians now pay about 50% more than the national average.



Perhaps the most glaring example: The California Legislature has mandated that one-half of the state's electricity come from renewable sources by 2030; today it's about one-fourth. That goal once was considered wildly optimistic. But solar panels have become much more efficient and less expensive. So solar power is now often the same price or cheaper than most other types of electricity, and production has soared so much that the target now looks laughably easy to achieve.

At the same time, however, state regulators — who act independently of the Legislature — until recently have continued to greenlight utility company proposals to build more natural gas power plants.



State Senate Leader Kevin de Leon (D-Los Angeles) wants Calilfornia to produce 100% of its electricity from clean energy sources such as solar and wind by 2045. (Luis Sinco/Los Angeles Times)

These conflicting energy agendas have frustrated state Senate Leader Kevin de Leon (D-Los Angeles), who opposes more fossil fuel plants. He has introduced legislation that would require the state to meet its goal of 50% of its electricity from renewable sources five years earlier, by 2025. Even more ambitiously, he recently proposed legislation to require 100% of the state's power to come from renewable energy sources by 2045.

"I want to make sure we don't have two different pathways," de Leon said. Expanding clean energy production and also building natural gas plants, he added, is "a bad investment."

Environmental groups are even more critical. They contend that building more fossil fuel plants at the same time that solar production is being curtailed shows that utilities — with the support of regulators — are putting higher profits ahead of reducing greenhouse gas emissions.

"California and others have just been getting it wrong," said Leia Guccione, an expert in renewable energy at the Rocky Mountain Institute in Colorado, a clean power advocate. "The way [utilities] earn revenue is building stuff. When they see a need, they are perversely [incentivized] to come up with a solution like a gas plant."

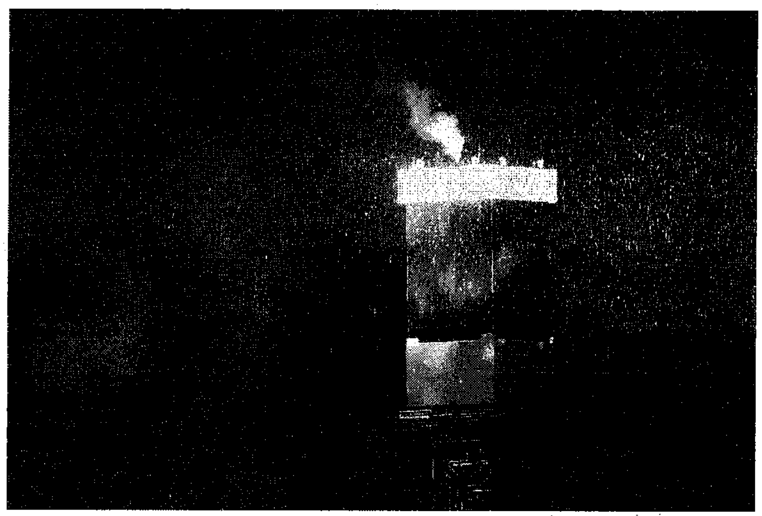
California and others have just been getting it wrong.

— Leia Guccione, renewable energy expert at the Rocky Mountain Institute

Regulators and utility officials dispute this view. They assert that the transition from fossil fuel power to renewable energy is complicated and that overlap is unavoidable.

They note that electricity demand fluctuates — it is higher in summer in California, because of air conditioning, and lower in the winter — so some production capacity inevitably will be underused in the winter. Moreover, the solar power supply fluctuates as well. It peaks at midday, when the sunlight is strongest. Even then it isn't totally reliable.

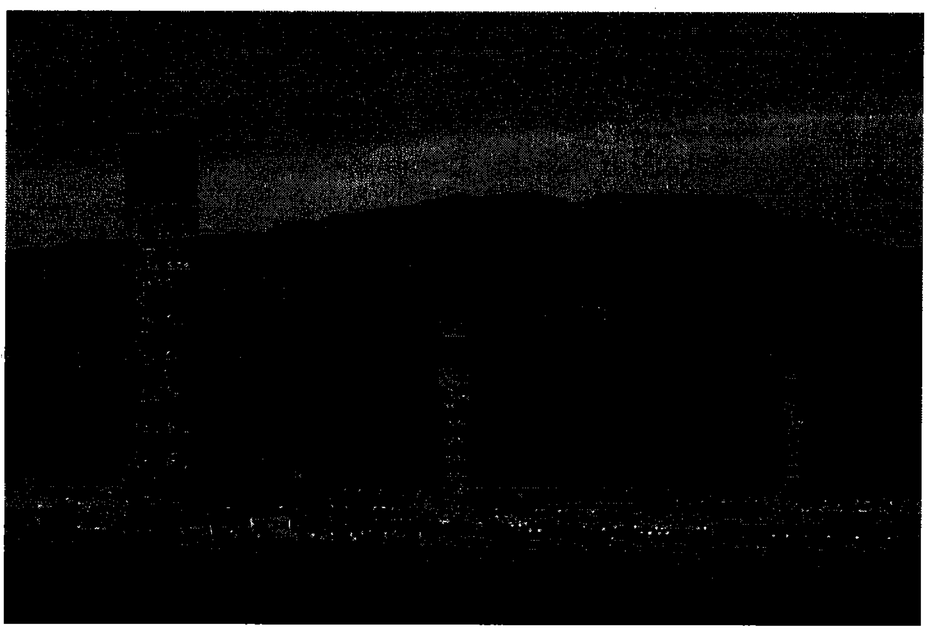
Because no one can be sure when clouds might block sunshine during the day, fossil fuel electricity is needed to fill the gaps. Utility officials note that solar production is often cut back first because starting and stopping natural gas plants is costlier and more difficult than shutting down solar panels.



In the Mojave Desert at the California/Nevada border, the Ivanpah Solar Electric Generating System uses 347,000 garage-door-sized mirrors to heat water that powers steam generators. This solar thermal plant — one of the clean energy facilities that helps produce 10% of the state's electricity. (Mark Boster / Los Angeles Times)

Eventually, unnecessary redundancy of electricity from renewables and fossil fuel will disappear, regulators, utilities and operators of the electric grid say.

"The gas-fired generation overall will show decline," said Neil Millar, executive director of infrastructure at CAISO, the California Independent System Operator, which runs the electric grid and shares responsibility for preventing blackouts and brownouts. "Right now, as the new generation is coming online and the older generation hasn't left yet, there is a bit of overlap."



Utility critics acknowledge these complexities. But they counter that utilities and regulators have been slow to grasp how rapidly technology is transforming the business. A building slowdown is long overdue, they argue.

Despite a growing glut of power, however, authorities only recently agreed to put on hold proposals for some of the new natural gas power plants that utilities want to build to reconsider whether they are needed.

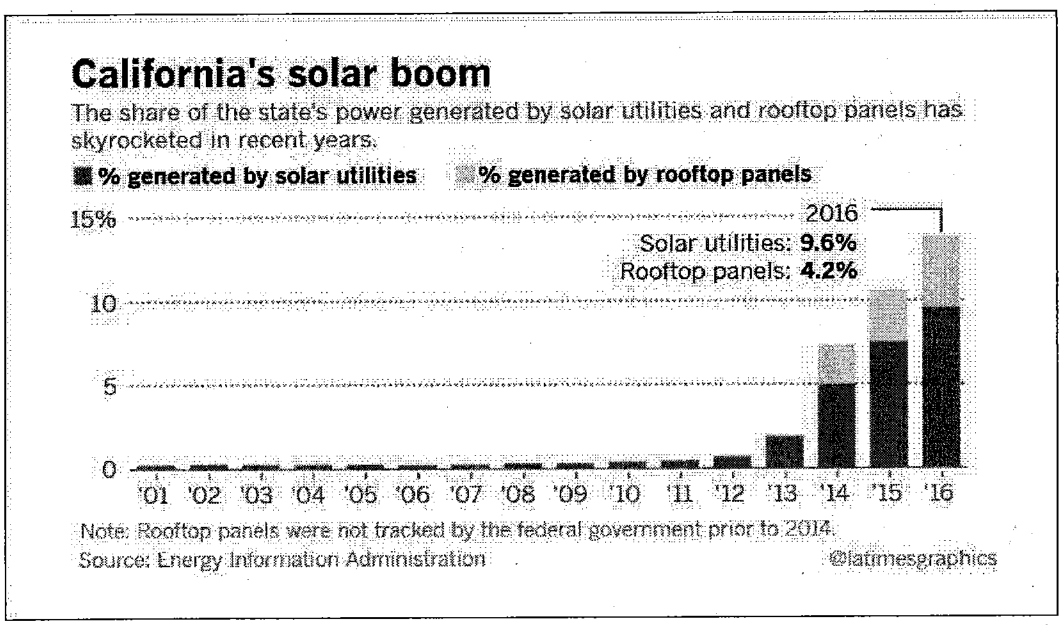
A key question in the debate is when California will be able to rely on renewable power for most or all of its needs and safely phase out fossil fuel plants, which regulators are studying.

The answer depends in large part on how fast battery storage improves, so it is cheaper and can store power closer to customers for use when the sun isn't shining. Solar proponents say the technology is advancing rapidly, making reliance on renewables possible far sooner than previously predicted, perhaps two decades or even less from now — which means little need for new power plants with a life span of 30 to 40 years.

Calibrating this correctly is crucial to controlling electricity costs.

"It's not the renewables that's the problem. It's the state's renewable policy that's the problem," said Gary Ackerman, president of the Western Power Trading Forum, an association of independent power producers. "We're curtailing renewable energy in the summertime months. In the spring, we have to give people money to take it off our hands."

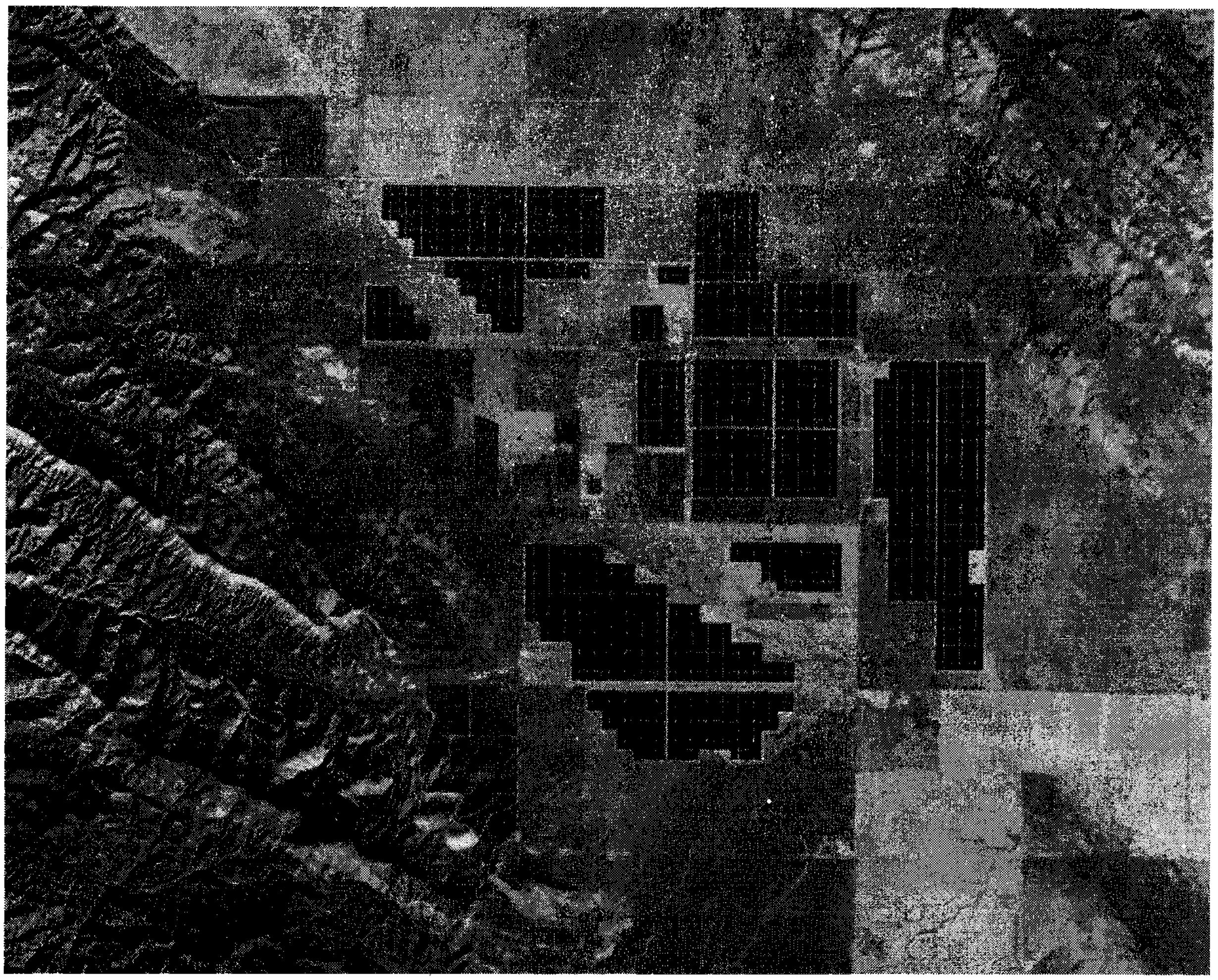
Not long ago, solar was barely a rounding error for California's energy producers.



In 2010, power plants in the state generated just over 15% of their electricity production from renewable sources. But that was mostly wind and geothermal power, with only a scant 0.5% from solar. Now that overall amount has grown to 27%, with solar power accounting for 10%, or most of the increase. The solar figure doesn't include the hundreds of thousands of rooftop solar systems that produce an additional 4 percentage points, a share that is ever growing.

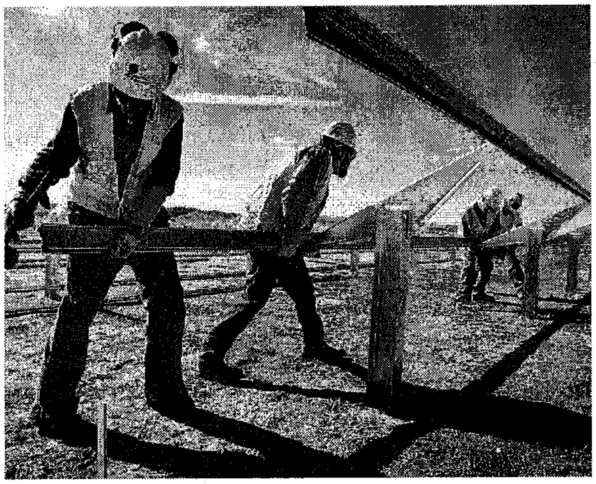
Source: Energy Information Administration California's solar boom The share of the state's power generated by solar utilities and rooftop panels has skyrocketed in recent years.

Behind the rapid expansion of solar power: its plummeting price, which makes it highly competitive with other electricity sources. In part that stems from subsidies, but much of the decline comes from the sharp drop in the cost of making solar panels and their increased efficiency in converting sunlight into electricity.



The average cost of solar power for residential, commercial and utility-scale projects declined 73% between 2010 and 2016. Solar electricity now costs 5 to 6 cents per kilowatt-hour — the amount needed to light a 100-watt bulb for 10 hours — to produce, or about the same as electricity produced by a natural gas plant and half the cost of a nuclear facility, according to the U.S. Energy Information Administration.

Fly over the Carrizo Plain in California's Central Valley near San Luis Obispo and you'll see that what was once barren land is now a sprawling solar farm, with panels covering more than seven square miles — one of the world's largest clean-energy projects. When the sun shines over the Topaz Solar Farm, the shimmering panels produce enough electricity to power all of the residential homes in a city the size of Long Beach, population 475,000.



A construction crew installs rails to support some of the 9 million solar panels at the Topaz Solar Farm near San Luis Obispo. (Joe Johnston / San Luis Obispo Tribune) The Topaz Solar Farm, one of the world's largest solar plants, blankets the Carrizo Plain in the Central Valley. It supplies electricity to Pacific Gas & Electric Co. (NASA)

Other large-scale solar operations blanket swaths of the Mojave Desert, which has increasingly become a sun-soaking energy hub. The Beacon solar project covers nearly two square miles and the Ivanpah plant covers about five and a half square miles.

The state's three big shareholder-owned utilities now count themselves among the biggest solar power producers. Southern California Edison produces or buys more than 7% of its electricity from solar generators, Pacific Gas & Electric 13% and San Diego Gas & Electric 22%.

Similarly, fly over any sizable city and you'll see warehouses, businesses and parking lots with rooftop solar installations, and many homes as well.

With a glut of solar power at times, CAISO has two main options to avoid a system overload: order some solar and wind farms to temporarily halt operations or divert the excess power to other states.

That's because too much electricity can overload the transmission system and result in power outages, just as too little can. Complicating matters is that even when CAISO requires large-scale solar plants to shut off panels, it can't control solar rooftop installations that are churning out electricity.

CAISO is being forced to juggle this surplus more and more.

In 2015, solar and wind production were curtailed about 15% of the time on average during a 24-hour period. That rose to 21% in 2016 and 31% in the first few months of this year. The surge in solar production accounts for most of this, though heavy rainfall has increased hydroelectric power production in the state this year, adding to the surplus of renewables.

July '14 Jan. '15 July Jan. '16 July Jan. '17 0 30K 60K 90K Volume of power curtailments (in megawatt-hours) P. Krishnakumar / @latimesgraphics Source: Cal-ISO March '1782,083megawatt-hours Pulling the plug California's clean energy supply is growing so fast that solar and wind producers are increasingly being ordered to halt production.

Even when solar production is curtailed, the state can produce more than it uses, because it is difficult to calibrate supply and demand precisely. As more homeowners install rooftop solar, for example, their panels can send more electricity to the grid than anticipated on some days, while the state's overall power usage might fall below what was expected.

This means that CAISO increasingly has excess solar and wind power it can send to Arizona, Nevada and other states.

When those states need more electricity than they are producing, they pay California for the power. But California has excess power on a growing number of days when neighboring states don't need it, so California has to pay them to take it. CAISO calls that "negative pricing."

Why does California have to pay rather than simply give the power away free?

When there isn't demand for all the power the state is producing, CAISO needs to quickly sell the excess to avoid overloading the electricity grid, which can cause blackouts. Basic economics kick in. Oversupply causes prices to fall, even below zero. That's because Arizona has to curtail its own sources of electricity to take California's power when it doesn't really need it, which can cost money. So Arizona will use power from California at times like this only if it has an economic incentive — which means being paid.

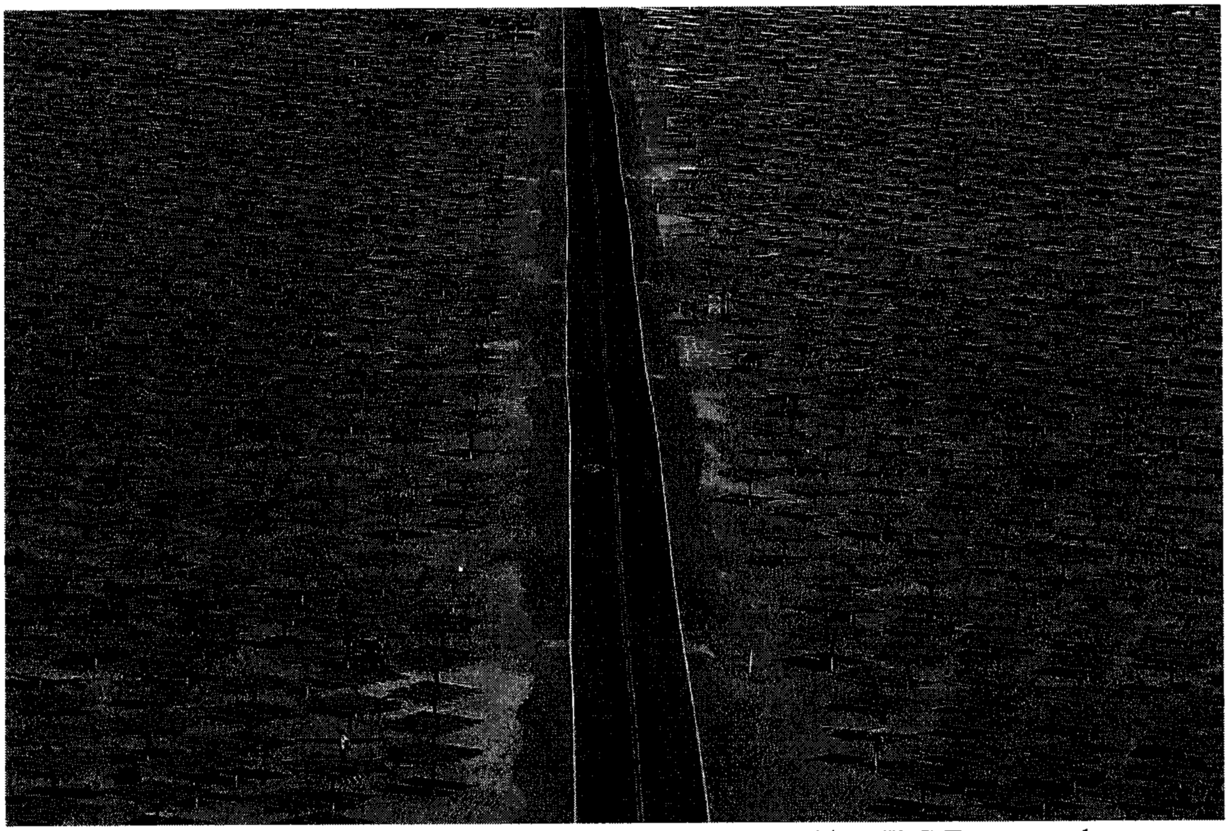
In the first two months of this year, CAISO paid to send excess power to other states seven times more often than same period in 2014. "Negative pricing" happened in an average of 18% of all sales, versus about 2.5% in the same period in 2014.

Most "negative pricing" typically has occurred for relatively short periods at midday, when solar production is highest.

But what happened in March shows how the growing supply of solar power could have a much greater impact in the future. The periods of "negative pricing" lasted longer than in the past — often for six hours at a time, and once for eight hours, according to a CAISO report.

The excess power problem will ease somewhat in the summer, when electricity usage is about 50% higher in California than in the winter.

But CAISO concedes that curtailments and "negative pricing" is likely to happen even more often in the future as solar power production continues to grow, unless action is taken to better manage the excess electricity.



The sprawling Ivanpah Solar Electric Generating System, owned by NRG Energy and BrightSource Energy, occupies 5.5 square miles in the Mojave Desert. The plant can supply electricity to 180,000 Pacific Gas & Electric and Southern California Edison customers. (Mark Boster/Los Angeles Times)

Arizona's largest utility, Arizona Public Service, is one of the biggest beneficiaries of California's largesse because it is next door and the power can easily be sent there on transmission lines.

On days that Arizona is paid to take California's excess solar power, Arizona Public Service says it has cut its own solar generation rather than fossil fuel power. So California's excess solar isn't reducing greenhouse gases when that happens.

CAISO says it does not calculate how much it has paid others so far this year to take excess electricity. But its recent oversupply report indicated that it frequently paid buyers as much as $25 per megawatt-hour to get them to take excess power, according to the Energy Information Administration.

That's a good deal for Arizona, which uses what it is paid by California to reduce its own customers' electricity bills. Utility buyers typically pay an average of $14 to $45 per megawatt-hour for electricity when there isn't a surplus from high solar power production.

With solar power surging so much that it is sometimes curtailed, does California need to spend $6 billion to $8 billion to build or refurbish eight natural gas power plants that have received preliminary approval from regulators, especially as legislative leaders want to accelerate the move away from fossil fuel energy?

The answer depends on whom you ask.

Utilities have repeatedly said yes. State regulators have agreed until now, approving almost all proposals for new power plants. But this month, citing the growing electricity surplus, regulators announced plans to put on hold the earlier approvals of four of the eight plants to determine if they really are needed.

Big utilities continue to push for all of the plants, maintaining that building natural gas plants doesn't conflict with expanding solar power. They say both paths are necessary to ensure that California has reliable sources of power — wherever and whenever it is needed.

The biggest industrial solar power plants, they note, produce electricity in the desert, in some cases hundreds of miles from population centers where most power is used.

At times of peak demand, transmission lines can get congested, like Los Angeles highways. That's why CAISO, utilities and regulators argue that new natural gas plants are needed closer to big cities. In addition, they say, the state needs ample electricity sources when the sun isn't shining and the wind isn't blowing enough.

Utility critics agree that some redundancy is needed to guarantee reliability, but they contend that the state already has more than enough.

California has so much surplus electricity that existing power plants run, on average, at slightly less than one-third of capacity. And some plants are being closed decades earlier than planned.

As for congestion, critics note that the state already is crisscrossed with an extensive network of transmission lines. Building more plants and transmission lines wouldn't make the power system much more reliable, but would mean higher profits for utilities, critics say.

That is what the debate is about, said Jaleh Firooz, a power industry consultant who previously worked as an engineer for San Diego Gas & Electric for 24 years and helped in the formation of CAISO.

"They have the lopsided incentive of building more," she said.

Jaleh Firooz, who worked 24 years as an engineer for San Diego Gas & Electric Co., says utilities seeking higher profits "have the lopsided incentive of building more" power plants and transmission lines. (Robert Gauthier/Los Angeles Times)

The reason: Once state regulators approve new plants or transmission lines, the cost is now built into the amount that the utility can charge electricity users — no matter how much or how little it is used.

Given that technology is rapidly tilting the competitive advantage toward solar power, there are less expensive and cleaner ways to make the transition toward renewable energy, she said.

To buttress her argument, Firooz pointed to a battle in recent years over a natural gas plant in Redondo Beach.

Independent power producer AES Southland in 2012 proposed replacing an aging facility there with a new one. The estimated cost: $250 million to $275 million, an amount that customers would pay off with higher electricity bills.

CAISO and Southern California Edison, which was going to buy power from the new plant, supported it as necessary to protect against potential power interruptions. Though solar and wind power production was increasing, they said those sources couldn't be counted on because their production is variable, not constant.

The California Public Utilities Commission approved the project, agreeing that it was needed to meet the long-term electricity needs in the L.A. area.

But the California Coastal Conservancy, a conservation group opposed to the plant, commissioned an analysis by Firooz to determine how vital it was. Her conclusion: not at all.

Firooz calculated that the L.A. region already had excess power production capacity — even without the new plant — at least through 2020.

Along with the cushion, her report found, a combination of improved energy efficiency, local solar production, storage and other planning strategies would be more than sufficient to handle the area's power needs even as the population grew.

She questioned utility arguments.

"In their assumptions, the amount of capacity they give to the solar is way, way undercut because they have to say, 'What if it's cloudy? What if the wind is not blowing?' " Firooz explained. "That's how the game is played. You build these scenarios so that it basically justifies what you want."

In their assumptions, the amount of capacity they give to the solar is way, way undercut because they have to say, 'What if it's cloudy?'

— Jaleh Firooz, power-industry consultant

Undeterred, AES Southland pressed forward with its proposal. In 2013, Firooz updated her analysis at the request of the city of Redondo Beach, which was skeptical that a new plant was needed. Her findings remained the same.

Nonetheless, the state Public Utilities Commission approved the project in March 2014 on the grounds that it was needed. But the California Energy Commission, another regulatory agency whose approval for new plants is required along with the PUC's, sided with the critics. In November 2015 it suspended the project, effectively killing it.

Asked about the plant, AES said it followed the appropriate processes in seeking approval. It declined to say whether it still thinks that a new plant is needed.

The existing facility is expected to close in 2020.

A March 2017 state report showed why critics are confident that the area will be fine without a new plant: The need for power from Redondo Beach's existing four natural gas units has been so low, the state found, that the units have operated at less than 5% of their capacity during the last four years.

Contact the reporter. For more coverage follow @ivanlpenn

Credits: Times data editor Ben Welsh and staff writer Ryan Menezes contributed to this report. Illustrations by Eben McCue. Graphics by Priya Krishnakumar and Thomas Suh Lauder. Produced by Sean Greene

The New York Times | https://nyti.ms/2GfH7Hm

ENERGY & ENVIRONMENT

It's the No. 1 Power Source, but Natural Gas Faces Headwinds

By IVAN PENN MARCH 28, 2018

As environmental concerns drive power companies away from using coal, natural gas has emerged as the nation's No. 1 power source. Plentiful and relatively inexpensive as a result of the nation's fracking boom, it has been portrayed as a bridge to an era in which alternative energy would take primacy.

But technology and economics have carved a different, shorter pathway that has bypassed the broad need for some fossil-fuel plants. And that has put proponents of natural gas on the defensive.

Some utility companies have scrapped plans for new natural-gas plants in favor of wind and solar sources that have become cheaper and easier to install. Existing gas plants are being shut because their economics are no longer attractive. And regulators are increasingly challenging the plans of companies determined to move forward with new natural-gas plants.

literally be put on a train and brought online within a year. It is moving so fast that even critics of the old path like myself have been taken by surprise."

The shifting dynamics are being seen in the Western states in particular — driven not only by economics, but by regulation and climate as well.

The Arizona Corporation Commission, which regulates the state's investor-owned utilities, recently refused to endorse plans by three power companies that included more natural-gas facilities. Commissioners directed them to make greater use of energy storage and plants that produce zero emissions.

"It's very erratic what we're now doing with power," said Andrew M. Tobin, an Arizona commissioner who led efforts to block new gas plants. "I am so nervous that we will end up building a lot of capital plant that doesn't stand the test of time."

Some feel the push to get beyond natural gas may be too much, too soon. Officials at Arizona Public Service, the largest utility in the state, said they needed to include new natural-gas development as part of an overall mix, partly because of the state's round-the-clock air-conditioning demands.

"Our needs are different than other utilities," said Greg Bernosky, the utility's director of state regulation and compliance. "We need resources that can have a long duration when our load is high, well after the sun has set. Natural gas resources provide that flexibility."

Nationwide, other utility executives, power producers and federal regulators have also argued that a healthy power grid requires consistent power, even when the sun doesn't shine or the wind ceases to blow. The more solar and wind power that is added to the electric grid, they say, the greater the need for reliable backup sources like natural gas.

"Gas has got to be part of that equation," Robert F. Powelson, a

And he argued that even recent advances in storage did not justify an overreliance on alternative energy, however inexpensive. "Storage is great," said Mr. Powelson, a nominee of President Trump and a former chairman of the Pennsylvania Public Utility Commission. "But that is not a reliable long-term solution to the energy markets."

Natural gas isn't likely to be unseated as the country's primary source of electricity generation anytime soon. In fact, utility companies plan to add more natural-gas plants than any other source, including all alternative energy sources, like solar, wind and hydropower, combined.

But the calculus is rapidly shifting as the prices of wind and solar power continue to fall. According to the Department of Energy, power generated by natural gas declined 7.7 percent in 2017.

And the latest report by Lazard, the financial advisory and management firm, found that the cost of power from utility-scale solar farms was now on a par with natural-gas generation — and that wind farms were less expensive still.

Lazard calculated the unsubsidized cost of wind power at 3 cents a kilowatt-hour, while natural gas and solar energy were a little more than 4 cents. The typical American household pays 12.5 cents a kilowatt-hour for electricity, according to the United States Energy Information Administration. (The cost beyond generation reflects transmission, taxes, and other utility expenses and profits.)

Moreover, the market equation in the West is driven largely by California, the sixth-largest economy in the world, which has mandated that 50 percent of its power be generated from renewable sources by 2030. With a regional energy market run by the state's electricity grid overseer, the California Independent System Operator, fossil-fuel plants have had increasing difficulty demanding that utilities rethink how they manage their systems to reduce carbon emissions.

Some power producers have bristled at the mandates, even scaling back their operations in certain markets because, they said, it became too difficult to compete without losing money.

NRG Energy, for example, announced this month that it would close three natural-gas plants in California because of the regulatory push for clean energy.

After NRG's announcement, Calpine, a power company based in Houston, said it would suspend plans to build a natural-gas plant in California.

"We cannot invest a single dollar in California," Thad Hill, Calpine's chief executive, said. "I would not call California a true competitive market."

But a big Oregon utility, Portland General Electric, has embraced clean-energy mandates to ease it off dependence on fossil fuels.

"First off for us, climate change is real and we have to diversify our mix," Dave Robertson, the company's vice president for public policy. "We're driving more and more toward a decarbonized future. We really feel like we've got to own that. It's really where the science is taking us."

This month, Portland General entered into an agreement to buy surplus hydropower from the Bonneville Power Administration — the surplus arises largely from California's turn to other renewable sources — helping the utility avoid construction of natural-gas plants to replace a coal facility.

"There are surpluses of energy that are looking for markets," said Brett Sims, Portland General's director of strategic planning and resource strategy.

Distributed Generation

Helpful Information & Documents

Renewable Energy System Owners

Renewable Energy works at Kittitas PUD with the help of the Washington State Department of Revenues Renewable Energy Cost Recovery Incentive Payment Program. Kittitas PUD administers this program on behalf of the DOR annually from July 1st through the following June 30th to qualifying customers in accordance with WAC 458-20-273. This program allows individuals that generate electricity from solar power, wind power or anaerobic digesters to receive a production incentive. Incentives are capped and the program expires June 30, 2020.

Washington State DOR Incentive Cap Update

On July 7, 2017 the Washington State Legislation passed Senate Bill 5939 that promotes a sustainable, local renewable energy industry through modifying renewable energy system tax incentives and providing guidance for renewable energy system component recycling.
Kittitas PUD is currently reviewing this legislation in order to modify our Distributed Generation program to be in compliance with this legislation. It is the decision of the District that we will not approve any new systems until this review is complete.
The District will accept applications for projects to secure a place "line" on a first come first served basis once the Districts review is complete. All applicants and known installers will be sent an updated applicant packet upon review completion. Customers can either apply online or the application can be found here and printed out to send in.

Distributed Generation application checklist
Distributed Generation Application
Power Purchase and Interconnection Agreement

Renewable Energy System Cost Recovery Annual Incentive Payment Application
A copy of this document can be located electronically here.

Renewable Energy System Cost Recovery Certification
A copy of your State approved Certification is required to be submitted with your payment application for new customers. If you have submitted your certification previously we have a copy in your customer file and you do not need to send another copy at this time.

If you would like more information on this program WAC 458-20-273 "Renewable energy system cost recovery" explains in depth the rules and regulations for this program.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment

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National Renewable Energy Laboratory

Prepared under Task No. SS13.1040

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Technical Report
NREL/TP-6A20-65298
January 2016

Contract No. DE-AC36-08GO28308

Executive Summary

This report quantifies the technical potential of photovoltaic (PV) systems deployed on rooftops in the continental United States, estimating how much energy could be generated by installing PV on all suitable roof area. The results do not exclude systems based on their economic performance, and thus they provide an upper bound on potential deployment rather than a prediction of actual deployment.

Although methods have been developed to estimate rooftop PV technical potential at the individual building level, previous estimates at the regional and national levels have lacked a rigorous foundation in geospatial data and statistical analysis. This report helps fill this gap by providing a detailed data-driven analysis of U.S. (national, state, and ZIP-code level) rooftop PV availability and technical electricity-generation potential. First, we use light detection and ranging (lidar) data, geographic information system (GIS) methods, and PV-generation modeling to calculate the suitability of rooftops for hosting PV in 128 cities nationwide—representing approximately 23% of U.S. buildings—and we provide PV-generation results for a subset of these cities. Second, we extend the insights from this analysis of areas covered by lidar data to the entire continental United States. We develop two statistical models—one for small buildings and one for medium and large buildings—that estimate the total amount of roof area suitable for hosting PV systems, and we simulate the productivity of PV modules on the roof area to arrive at the nationwide technical potential for PV.

Our analysis of the trends in the suitability of rooftops for hosting PV systems reveals important variations in this key driver of rooftop PV technical potential that have not been captured by previous approaches. Figure ES-1 shows the results—from our statistical modeling grounded in lidar data—for the percentage of small buildings that are suitable for PV in each ZIP code in the continental United States. In the figure we can identify regional trends in the suitability of small building rooftops, with high densities of suitable small buildings in California, Florida, and the West South Central census division. Such trends are also critical to estimating PV technical potential at finer resolution, and our report illustrates this with a high-resolution analysis of 11 representative cities.

Figure ES-2 shows the annual energy generation potential from rooftop PV as a percentage of each state's electricity sales in 2013. The estimates of energy generation are based on the rooftop suitability of small, medium, and large buildings as well as specific roof orientations, local solar resources, PV system performance assumptions, and building footprints.[1]

[1] Because the medium and large building estimates are available only at the state level, the combined results are presented at that level.

Figure ES-2 shows that California has the greatest potential to offset electricity use—its rooftop PV could generate 74% of the electricity sold by its utilities in 2013. A cluster of New England states could generate more than 45% because these states' low per-capita electricity consumption offsets their below-average solar resource. Washington, with the lowest population-weighted solar resource in the continental United States, could still generate 27%. Some states with below-average solar resource (such as Minnesota, Maine, New York, and South Dakota) have similar or even greater potential to offset total sales compared to states with higher-quality resource (such as Arizona and Texas).

The difference between Florida and other South Atlantic states illustrates the interplay between variables that affect technical potential. Florida can offset 47% of its total consumption despite having an average household consumption of 130% of the national average. This is largely explained by significantly below-average electricity consumption outside of the residential sector, which makes the state's total per-capita electricity sales slightly lower than the national average. In contrast, the other South Atlantic states range from a potential 23% to 35% of electricity offset owing to lower average rooftop suitability (see Figure ES-1[2]), slightly lower quality solar resource, and higher per-capita total electricity sales.

Table ES-1 shows our aggregate results.[3] The total national technical potential of rooftop PV is 1,118 gigawatts (GW) of installed capacity and 1,432 terawatt-hours (TWh) of annual energy generation. This equates to 39% of total national electric-sector sales, and it is significantly greater than a previous National Renewable Energy Laboratory estimate of 664 GW of installed capacity and 800 TWh of annual energy generation (Denholm and Margolis 2008). The difference can be attributed to increases in module power density, improved estimation of building suitability, higher estimates of the total number of buildings, and improvements in PV performance simulation tools that previously tended to underestimated production.

Although only 26% of the total rooftop area on small buildings (those with a footprint smaller than 5,000 ft^2) is suitable for PV deployment, the sheer number of buildings in this class gives small buildings the greatest technical potential. Small building rooftops could accommodate 731 GW of PV capacity and generate 926 TWh/year of PV energy, which represents approximately 65% of rooftop PV's total technical potential. Medium and large buildings have a total installed capacity potential of 386 GW and energy generation potential of 506 TWh/year, which represents approximately 35% of the total technical potential of rooftop PV.

These results are sensitive to assumptions about module performance, which is expected to continue improving over time. For example, this analysis assumed a module efficiency of 16% to represent a mixture of various technology types. If a module efficiency of 20% were assumed instead, which corresponds to current premium systems, each of the technical potential estimates would increase by about 25% above the values stated in this report. Furthermore, our results are only estimates of the potential from existing suitable roof planes, and they do not consider the immense potential of ground-mounted PV. Actual generation from PV in urban areas could exceed these estimates by

[2] Figure ES-1 shows suitability results for only small buildings because more than 99% of medium and large buildings have at least one roof plane suitable for a PV system.

[3] Because the relative magnitudes of the results are a strong function of the square footage used as a cutoff between building classes, these results should not be presented without that information.

installing systems on less suitable roof area, mounting PV on canopies over open spaces such as parking lots, or integrating PV into building facades.

Because our results are estimates of technical potential, they do not consider what would be required to use all the potential PV-generated energy. In practice, the integration of a significant quantity of rooftop PV into the national portfolio of generation capacity would require a flexible grid, supporting infrastructure, and a suite of enabling technologies.

Table ES-1. Estimated Suitable Area and Rooftop PV Technical Potential by Building Class

Building Class (Building Footprint)	Total Suitable Area (Billions of m^2)	Installed Capacity Potential (GW)	Annual Generation Potential (TWh/year)	Annual Generation Potential (% of National Sales)
Small (< 5,000 ft^2)	4.92	731	926	25.0%
Medium (5,000–25,000 ft^2)	1.22	154	201	5.4%
Large (> 25,000 ft^2)	1.99	232	305	8.2%
All Buildings	**8.13**	**1,118**	**1,432**	**38.6%**

Many opportunities exist for expanding on the data, methods, and results from this report. Our base data set can be combined with numerous other data sets—such as insolation data, market data, and end-use electricity consumption data—to provide more precise and actionable information than has been available previously. To that end and to encourage municipalities, utility providers, solar energy researchers, and other PV stakeholders to use the data for their own purposes, we have posted supporting data and documentation of the methods we used to perform our analysis on the NSRDB Data Viewer website.[4] The models developed here also can be applied generally in areas where lidar data may not be available, both for making estimates of rooftop areas for arbitrary geographies and in stochastic simulations where statistically representative buildings are needed.

[4] See maps.nrel.gov/pv-rooftop-lidar.

Table 5. Estimated Rooftop PV Technical Potential of Medium and Large Buildings by State

State	Annual Generation Potential (% of sales)	Installed Capacity Potential (GW)	Annual Generation Potential (TWh/year)	Total Roof Area Suitable for PV Deployment (millions of m^2)
California	30.6%	52.2	80.0	435.3
Rhode Island	25.4%	1.6	2.0	13.7
Connecticut	22.1%	5.6	6.6	46.3
Massachusetts	21.5%	10.1	11.9	82.4
New Hampshire	21.0%	2.0	2.3	16.5
Maine	20.1%	2.1	2.4	16.7
Vermont	19.7%	1.0	1.1	7.9
Nevada	18.0%	3.9	6.4	33.8
Maryland	17.3%	8.5	10.7	70.4
Colorado	16.9%	6.1	9.0	51.9
Oklahoma	16.7%	7.2	10.0	59.5
Florida	16.2%	25.9	35.9	213.6
New Jersey	15.5%	9.3	11.6	79.0
Minnesota	15.4%	9.1	10.6	75.7
Michigan	15.3%	13.7	15.8	114.1
Missouri	14.5%	9.4	12.1	78.1
Kansas	14.3%	4.2	5.7	34.7
Nebraska	14.2%	3.3	4.4	27.7
Illinois	13.4%	15.7	19.0	131.6
Texas	12.7%	35.1	48.1	289.9
New York	12.6%	15.3	18.6	129.7
Wisconsin	12.6%	7.3	8.7	60.2
Ohio	12.2%	15.8	18.3	131.3
Georgia	12.2%	12.2	15.9	101.9
Virginia	11.8%	10.2	13.1	83.9
Louisiana	11.6%	7.6	9.9	62.6
North Carolina	11.4%	11.1	14.7	92.3
Pennsylvania	11.3%	14.0	16.5	116.8
Washington DC	10.9%	1.0	1.2	8.1
Oregon	10.8%	4.4	5.1	35.6
Arkansas	10.8%	3.9	5.0	31.9
Alabama	10.7%	7.2	9.4	58.6

State	Annual Generation Potential (% of sales)	Installed Capacity Potential (GW)	Annual Generation Potential (TWh/year)	Total Roof Area Suitable for PV Deployment (millions of m^2)
Iowa	10.7%	4.1	5.0	33.5
Mississippi	10.6%	3.9	5.2	31.8
New Mexico	10.6%	1.5	2.4	12.6
Tennessee	9.9%	7.4	9.6	60.4
South Dakota	9.3%	0.9	1.1	7.1
Kentucky	9.2%	6.4	7.8	52.9
Indiana	9.2%	8.0	9.7	65.9
Utah	9.1%	1.9	2.8	16.2
Delaware	9.0%	0.8	1.0	6.6
Washington	8.5%	7.1	7.8	[redacted]
South Carolina	6.6%	3.8	5.2	31.4
North Dakota	6.3%	0.8	1.0	6.7
West Virginia	5.6%	1.5	1.8	12.5
Idaho	4.2%	0.7	1.0	6.1
Arizona	2.8%	1.3	2.1	10.9
Wyoming	1.8%	0.2	0.3	1.7
Montana	1.3%	0.1	0.2	1.2
Continental U.S. Total	**13.6%**	**386.5**	**506.0**	**3,207.4**

Wild Horse Wind Facility

Monthly Compliance Report - July 2017

Below is the operational/compliance update for July. As requested by Chair Lynch, below is an update on the status of the Eagle Conservation Plan and Eagle Take Permit. Going forward, routine updates will be provided to EFSEC on a monthly basis. Please let me know if you have any questions.

Safety

No lost-time accidents or safety injuries/illnesses.

Compliance/Environmental

Nothing to report.

Operations/Maintenance

Nothing to report.

Wind Production

Generation totaled 54,057 MWh for an average capacity factor of 26.65%.

Eagle Update

- PSE has entered into a standard civil Settlement Agreement with USFWS to resolve the four eagle fatalities at Wild Horse. When developing the Settlement Agreement, the Service considered the previous actions PSE has taken in an effort to "mitigate" the fatalities such as providing funding to Hawk Watch International and Blue Mountain Wildlife Rehab, as well as conservation measures implemented under the SCA. Under the Settlement, PSE will implement corrective actions in the form or research and development of eagle detection and deterrent technologies and report to the USFWS.
- PSE continues to work closely with USFWS on revisions to the Eagle Conservation Plan and Environmental Assessment.
- Once the Eagle Conservation Plan is finalized, PSE will provide a copy to EFSEC and the TAC.
- Once the final Environmental Assessment (EA) is completed, the USFWS will release the EA in the Federal Register for public review and comment, then will make a determination on whether to issue an incidental eagle take permit.

Avian Mortality at Solar Energy Facilities in Southern California: A Preliminary Analysis

Rebecca A. Kagan, Tabitha C. Viner, Pepper W. Trail, and Edgard O. Espinoza
National Fish and Wildlife Forensics Laboratory

Executive Summary

This report summarizes data on bird mortality at three solar energy facilities in southern California: Desert Sunlight, Genesis, and Ivanpah. These facilities use different solar technologies, but avian mortality was documented at each site. Desert Sunlight is a photovoltaic facility, Genesis employs a trough system with parabolic mirrors, and Ivanpah uses a power tower as a focal point for solar flux.

Findings

Trauma was the leading cause of death documented for remains at the Desert Sunlight and Genesis sites. Trauma and solar flux injury were both major causes of mortality at the Ivanpah site. Exposure to solar flux caused singeing of feathers, which resulted in mortality in several ways. Severe singeing of flight feathers caused catastrophic loss of flying ability, leading to death by impact with the ground or other objects. Less severe singeing led to impairment of flight capability, reducing ability to forage and evade predators, leading to starvation or predation. Our examinations did not find evidence for significant tissue burns or eye damage caused by exposure to solar flux.

Cause of Death	Ivanpah	Genesis	Desert Sunlight	Total
Solar Flux	47	0	0	47
Impact trauma	24	6	19	49
Predation trauma	5	2	15	22
Trauma of undetermined cause	14	0	0	14
Electrocution	1	0	0	1
Emaciation	1	0	0	1
Undetermined (remains in poor condition)	46	17	22	85
No evident cause of death	3	6	5	14
Total	141	31	61	233

These solar facilities appear to represent "equal-opportunity" hazards for the bird species that encounter them. The remains of 71 species were identified, representing a broad range of ecological types. In body size, these ranged from hummingbirds to pelicans; in ecological type from strictly aerial feeders

(swallows) to strictly aquatic feeders (grebes) to ground feeders (roadrunners) to raptors (hawks and owls). The species identified were equally divided among resident and non-resident species, and nocturnal as well as diurnal species were represented. Although not analyzed in detail, there was also significant bat and insect mortality at the Ivanpah site, including monarch butterflies. It appears that Ivanpah may act as a "**mega-trap,**" attracting insects which in turn attract insect-eating birds, which are incapacitated by solar flux injury, thus attracting predators and creating an entire food chain vulnerable to injury and death.

			Foraging Zone			**Residency Status**	
SITE	No. Remains	Identifiable Remains	Air	Terr	Water	Resident	Migrant
Ivanpah	141	127	28	85	14	63	64
Genesis	31	30	12	12	6	20	10
Desert Sun	61	56	7	22	27	18	38
TOTALS	233	213	47	119	47	101	112

CONCLUSIONS AND RECOMMENDATIONS

In summary, three main causes of avian mortality were identified at these facilities: impact trauma, solar flux, and predation. Birds at all three types of solar plants were susceptible to impact trauma and predators. Predation was documented mostly at the photovoltaic site, and in many cases appeared to be associated with stranding or nonfatal impact trauma with the panels, leaving birds vulnerable to resident predators. Solar flux injury, resulting from exposures to up to 800° F, was unique to the power tower facility. Our findings demonstrate that a broad ecological variety of birds are vulnerable to morbidity and mortality at solar facilities, though some differential mortality trends were evident, such as waterbirds at Desert Sunlight, where open water sources were present; and insectivores at Ivanpah, where insects are attracted to the solar tower.

Specific hazards were identified, including vertically-oriented mirrors or other smooth reflective panels; water-like reflective or polarizing panels; actively fluxing towers; open bodies of water; aggregations of insects that attracted insectivorous birds; and resident predators. Making towers, ponds and panels less attractive or accessible to birds may mitigate deaths. Specific actions should include:

Monitoring/detection measures:

1) Install video cameras sufficient to provide 360 degree coverage around each tower to record birds (and bats) entering and exiting the flux

2) For at least two years (and in addition to planned monitoring protocol), conduct daily surveys for birds (at all three facilities), as well as insects and bats (in the condenser building at Ivanpah) around each tower at the base of and immediately adjacent to the towers in the area cleared of vegetation. Timing of daily surveys can be adjusted to minimize scavenger removal of carcasses as recommended by the TAC. Surveys in the late afternoon might be optimal for bird carcasses, and first light for bat carcasses.

3) Use dogs for monitoring surveys to detect dead and injured birds that have hidden themselves in the brush, both inside and outside the perimeter of the facility

4) To decrease removal of carcasses, implement appropriate raven deterrent actions

Bird Mortality Avoidance Measures:

1) Increase cleared area around tower at Ivanpah to decrease attractive habitat; at least out to fence

2) Retrofit visual cues to existing panels at all three facilities and incorporate into new panel design. These cues should include UV-reflective or solid, contrasting bands spaced no further than 28 cm from each other

3) Suspend power tower operation during peak migration times for indicated species

4) Avoid vertical orientation of mirrors whenever possible, for example tilt mirrors during washing

5) Properly net or otherwise cover ponds

6) Place perch deterrent devices where indicated, eg. on tower railings near the flux field

7) Employ exclusionary measures to prevent bats from roosting in and around the condenser facility at Ivanpah.

It must be emphasized that we currently have a very incomplete knowledge of the scope of avian mortality at these solar facilities. Challenges to data collection include: large facilities which are difficult to efficiently search for carcasses; vegetation and panels obscuring ground visibility; carcass loss due to scavenging; rapid degradation of carcass quality hindering cause of death and species determination; and inconsistent documentation of carcass history.

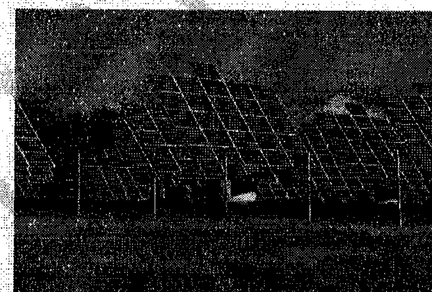
To rectify this problem, video cameras should be added to the solar towers to record bird mortality and daily surveys of the area at the base of and immediately adjacent to the towers should be conducted. At all the facilities, a protocol for systematic, statistically-rigorous searches for avian remains should be developed, emphasizing those areas where avian mortality is most likely to occur. Investigation into bat and insect mortalities at the power tower site should also be pursued.

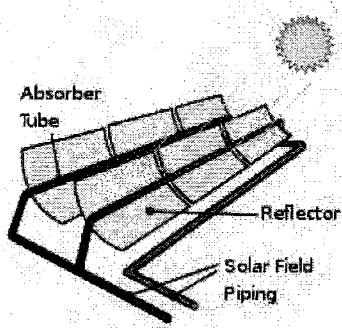
Finally, there are presently little data available on how solar flux affects birds and insects. Studies of the temperatures experienced by objects in the flux; of the effects of high temperatures on feather structure and function; and of the behavior of insects and birds in response to the flux and related phenomena (e.g. "light clouds") are all essential if we are to understand the scope of solar facility effects on wildlife.

Introduction

The National Fish and Wildlife Forensics Laboratory was requested to determine cause of death for birds found at facilities that generate electricity from solar energy. Solar generating facilities can be classified into three major types: photovoltaic sites, trough systems and solar power towers. There is much written about these systems so this report will not include any technical details, but simply mention the differences and their potential impact on birds.

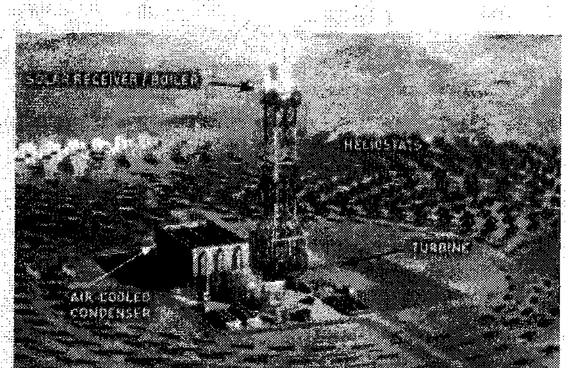
1) **Photovoltaic systems** directly convert the sun's light into electricity. The perceived threat to birds is associated with the presence of water ponds which attract birds and from traumatic impact with the photovoltaic cells. An example of this type of solar power plant is Desert Sunlight Solar Farm (AKA First Solar).





2) **Trough systems** are composed of parabolic mirrors which focus and reflect the sun to a tube that converts the heat from the sun into electricity. The perceived threat to birds is associated with the presence of water ponds which attract birds and from traumatic impact with the trough structures. An example of this type of solar power plant is Genesis Solar Energy Project.

3) **Solar power towers** use thousands of mirrors to reflect the solar energy to a tower, where water in a boiler is converted to steam, generating the electricity. The perceived threat to birds is associated traumatic impact with the mirrors and the danger associated with the heat produced by the mirrors. An example of this type of solar power plant is Ivanpah Solar Electric Generating System.



Methods

Carcasses were collected at the different solar power plant sites by either US Fish and Wildlife Service employees or by energy company staff. The collection of the carcasses was opportunistic; that is, not according to a pre-determined sampling schedule or protocol. There was no attempt to quantify the number of carcasses that scavengers or predators removed from the solar facilities' grounds, or to compare the distribution of carcasses inside and outside the boundaries of the solar facility sites.

Additionally, three USFWS/-OLE staff, including two Forensics Lab staff (EOE and RAK), visited the Ivanpah Solar plant from October 21 – 24, 2013. Their on-site observations are included in this report.

A total of 233 birds collected from three different facilities were examined; 141 from a solar thermal power tower site (Ivanpah, Bright Source Inc.), 31 from a parabolic trough site (Genesis, NextEra Energy Inc.) and 61 from a photovoltaic (PV) panel site (Desert Sunlight, First Solar Inc.). Nine of the Ivanpah birds were received fresh; 7 of those were necropsied during a site visit by a Forensics Laboratory pathologist (RAK). The rest of the birds were received frozen and allowed to thaw at room temperature prior to species identification and necropsy. Species determination was made by the Forensics Laboratory ornithologist (PWT) for all birds either prior to necropsy or, for those necropsied on-site, from photos and the formalin-fixed head. All data on carcass history (location of the carcass, date of collection and any additional observations) were transcribed, although these were not available for all carcasses.

As part of the gross pathological examination, whole carcasses were radiographed to help evaluate limb fractures and identify any metal foreign bodies. Alternate light source examination using an Omnichrome Spectrum 9000+ at 570 nm with a red filter helped rule in or out feather burns by highlighting subtle areas of feather charring (Viner et al., 2014). All birds or bird parts from Ivanpah without obvious burns were examined with the alternate light source, as well as any bird reportedly found near a power line and a random sub-sample of the remaining birds from Genesis and Desert Sunlight (Viner, T. C., R. A. Kagan, and J. L. Johnson, 2014, Using an alternate light source to detect electrically singed feathers and hair in a forensic setting. Forensic Science International, v. 234, p. e25-e29).

Carcass quality varied markedly. If carcasses were in good post mortem condition, representative sections of heart, lung, kidney, liver, brain and gastrointestinal tract as well as any tissues with gross lesions were collected and fixed in 10% buffered formalin. Full tissue sets were collected from the fresh specimens. Formalin-fixed tissues were routinely processed for histopathology, paraffin-embedded, cut at 4 µm and stained with hematoxylin and eosin. Tissues from 63 birds were examined microscopically; 41 from Ivanpah, 1 from Genesis and 21 from Desert Sunlight.

Birds with feather burns were graded based on the extent of the lesions. Grade 1 birds had curling of less than 50% of the flight feathers. Grade 2 birds had curling of 50% or more of the flight feathers. Grade 3 birds had curling and visible charring of contour feathers (Figure 1).

Figure 1: Three grades of flux injury based on extent and severity of burning. Grade 1 (top); Yellow-rumped Warbler with less than 50% of the flight feathers affected (note sparing of the yellow rump feathers). Grade 2 (middle); Northern Rough-winged Swallow initially found alive but unable to fly, with greater than 50% of the flight feathers affected. Grade 3 (bottom); MacGillivray's Warbler with charring of feathers around the head, neck, wings and tail.

Bird Species Recovered at Solar Power Facilities

Tables 1-4 and Appendix 1 summarize 211 identifiable bird remains recovered from the three solar facilities included in this study. These birds constitute a taxonomically diverse assemblage of 71 species, representing a broad range of ecological types. In body size, these species ranged from hummingbirds to pelicans; in ecological type from strictly aerial feeders (e.g. swifts and swallows) to strictly aquatic feeders (pelicans and cormorants) to ground feeders (roadrunners) to raptors (hawks and owls). The species identified were equally divided among resident and non-resident species. Nocturnal as well as diurnal species were represented.

In Tables 1-4 and Appendix 1, bird species are categorized into very general ecological types by foraging zone and residency status. Foraging Zones were "air" (a significant portion of foraging activity performed in the air), "terrestrial" (including foraging both in vegetation and on the ground), and "water" (foraging associated with water, including waders as well as aquatic birds). Residency Status was "resident" (for breeding or year-round residents) and "migrant" (for both passage migrants and non-breeding-season residents). For a number of species, the appropriate classification for residency status was uncertain, due to a lack of detailed knowledge of the sites. The present classification is based on published range maps, and is subject to revision as more information becomes available.

This dataset is not suitable for statistical analysis, due to the opportunistic and unstandardized collection of avian remains at the facilities, and the lack of baseline data on bird diversity and abundance at each site. Nevertheless, a few conclusions can be noted. First, these data do not support the idea that these solar facilities are attracting particular species. Of the 71 bird species identified in remains, only five species were recovered from all three sites. These five were American Coot, Mourning Dove, Lesser Nighthawk, Tree Swallow, and Brown-headed Cowbird, again emphasizing the ecological variety of birds vulnerable to mortality at the solar facilities. Over two-thirds (67%) of the species were found at only a single site

(Appendix 1). That being said, the Desert Sunlight facility had particularly high mortality among waterbirds, suggesting a need to render the ponds at that site inaccessible or unattractive to these species.

The diversity of birds dying at these solar facilities, and the differences among sites, suggest that there is no simple "fix" to reduce avian mortality. These sites appear to represent "equal-opportunity" mortality hazards for the bird species that encounter them. Actions to reduce or mitigate avian mortality at solar facilities will need to be designed on a site-specific basis, and will require much more data on the bird communities at each site, and on how mortality is occurring. Carefully-designed mortality studies might reveal significant patterns of vulnerability that are not evident in these data.

Table 1. Summary data on avian mortality at the three solar sites included in this study. See summary for discussion of Foraging Zone and Residency Status categories.

				Foraging Zone			Residency Status	
SITE	**No. Species**	**No. Remains**	**Identifiable Remains**	**Air**	**Terr**	**Water**	**Resident**	**Migrant**
Ivanpah	49	141	127	26	85	14	63	64
Genesis	15	31	30	12	12	6	20	10
Desert Sun	33	61	56	7	22	27	18	38
TOTALS	71	233	213	47	119	47	101	112

Table 2. Species identified from avian remains at the Desert Sunlight photovoltaic solar facility. MNI = minimum number of individuals of each species represented by the identifiable remains. In some cases (e.g. Cinnamon/Blue-winged Teal), closely related species could not be distinguished based on the available remains, but the Foraging Zone and Residency Status could still be coded, due to the ecological similarities of the species involved. Total identified birds = 56.

DESERT SUNLIGHT		Zone	Residency	MNI
Pied-billed Grebe	*Podilymbus podiceps*	water	migrant	1
Eared Grebe	*Podiceps nigricollis*	water	migrant	3
Sora	*Porzana carolina*	water	migrant	1
American Avocet	*Recurvirostra americana*	water	migrant	1
Cinnamon/Blue-winged Teal	*Anas discors/clypeata*	water	migrant	1
Western Grebe	*Aechmophorus occidentalis*	water	migrant	9
Brown Pelican	*Pelecanus occidentalis*	water	migrant	2
Double-crested Cormorant	*Phalacrocorax auritus*	water	migrant	2
Black-crowned Night-Heron	*Nycticorax nycticorax*	water	migrant	1
Yuma Clapper Rail	*Rallus longirostris*	water	resident	1
American Coot	*Fulica americana*	water	migrant	5
Mourning Dove	*Zenaida macroura*	terr	resident	3
White-winged Dove	*Zenaida asiatica*	terr	resident	1
Lesser Nighthawk	*Chordeiles acutipennis*	air	resident	2
Common Poorwill	*Phalaenoptilus nuttallii*	air	resident	1
Costa's Hummingbird	*Calypte costae*	air	resident	1
Ash-throated Flycatcher	*Myiarchus cinerascens*	air	resident	1
Black-throated/Sage Sparrow	*Amphispiza sp.*	terr	resident	1
Black Phoebe	*Sayornis nigricollis*	air	resident	1
Loggerhead Shrike	*Lanius ludovicianus*	terr	resident	2
Common Raven	*Corvus corax*	terr	resident	1
Horned Lark	*Eremophila alpestris*	terr	migrant	1
Tree Swallow	*Tachycineta bicolor*	air	migrant	1
Townsend's Warbler	*Setophaga townsendi*	terr	migrant	2
Common Yellowthroat	*Geothlypis trichas*	terr	migrant	1
Savannah Sparrow	*Passerculus sandwichensis*	terr	migrant	1
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	terr	migrant	1
Wilson's Warbler	*Cardellina pusilla*	terr	migrant	2
Western Tanager	*Piranga ludoviciana*	terr	migrant	2
Black-headed Grosbeak	*Pheucticus melanocephalus*	terr	migrant	1
Great-tailed Grackle	*Quiscalus mexicanus*	terr	resident	2
Brown-headed Cowbird	*Molothrus ater*	terr	resident	1

Table 3. Species identified from avian remains at the Genesis trough system solar facility. Total identified birds = 30.

GENESIS		Zone	Residency	MNI
Eared Grebe	*Podiceps nigricollis*	water	migrant	2
Great Blue Heron	*Ardea herodias*	water	migrant	1
American Kestrel	*Falco sparverius*	air	resident	1
Ring-billed Gull	*Larus delawarensis*	water	migrant	2
California Gull	*Larus californianus*	water	resident	1
White-winged Dove	*Zenaida asiatica*	terr	resident	1
Lesser Nighthawk	*Chordeiles acutipennis*	air	resident	2
Say's Phoebe	*Sayornis saya*	air	resident	2
Tree Swallow	*Tachycineta bicolor*	air	migrant	2
Cliff Swallow	*Petrochelidon pyrrhonota*	air	resident	5
Hermit Warbler	*Setophaga occidentalis*	terr	migrant	1
Black-headed Grosbeak	*Pheucticus melanocephalus*	terr	migrant	1
Chipping Sparrow	*Spizella passerina*	terr	resident	1
Bullock's Oriole	*Icterus bullockii*	terr	resident	2
Brown-headed Cowbird	*Molothrus ater*	terr	resident	6

Table 4. Species identified from avian remains at the Ivanpah power tower solar facility. Total identified birds = 127

IVANPAH		Zone	Residency	MNI
Cinnamon Teal	*Anas cyanoptera*	water	migrant	4
Cooper's Hawk	*Accipiter cooperii*	air	migrant	1
Red-shouldered Hawk	*Buteo lineatus*	terr	migrant	1
American Kestrel	*Falco sparverius*	air	resident	1
Peregrine Falcon	*Falco peregrinus*	air	resident	1
American Coot	*Fulica americana*	water	migrant	7
Sora	*Porzana carolina*	water	migrant	1
Spotted Sandpiper	*Actitis maculatus*	water	migrant	2
Greater Roadrunner	*Geococcyx californianus*	terr	resident	5
Yellow-billed Cuckoo	*Coccyzus americanus*	terr	migrant	1
Mourning Dove	*Zenaida macroura*	terr	resident	11
Barn Owl	*Tyto alba*	terr	resident	1
Lesser Nighthawk	*Chordeiles acutipennis*	air	resident	3
Common Poorwill	*Phalaenoptilus nuttallii*	air	resident	1
White-throated Swift	*Aeronautes saxatalis*	air	resident	1
Allen's/Rufous Hummingbird	*Selasphorus sp.*	air	migrant	1
Northern Flicker	*Colaptes auratus*	terr	resident	1
Ash-throated Flycatcher	*Myiarchus cinerascens*	air	resident	1
Loggerhead Shrike	*Lanius ludovicianus*	terr	resident	3
Warbling Vireo	*Vireo gilvus*	terr	migrant	1
Common Raven	*Corvus corax*	terr	resident	2
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	air	migrant	2
Tree Swallow	*Tachycineta bicolor*	air	migrant	2
Verdin	*Auriparus flaviceps*	terr	resident	3
Blue-gray Gnatcatcher	*Polioptila caerulea*	terr	resident	1
Northern Mockingbird	*Mimus polyglottos*	terr	resident	1
American Pipit	*Anthus rubescens*	terr	migrant	4
Orange-crowned Warbler	*Oreothlypis celata*	terr	migrant	1
Lucy's Warbler	*Oreothlypis luciae*	terr	resident	1
Black-throated Gray Warbler	*Setophaga nigrescens*	terr	migrant	1
Yellow-rumped Warbler	*Setophaga coronata*	air	migrant	14
Townsend's Warbler	*Setophaga townsendi*	terr	migrant	2
Yellow Warbler	*Setophaga petechia*	terr	migrant	1
Black-and-white Warbler	*Mniotilta varia*	terr	migrant	1
Wilson's Warbler	*Cardellina pusilla*	terr	migrant	2
MacGillivray's Warbler	*Oporornis tolmei*	terr	migrant	1
Western Tanager	*Piranga ludoviciana*	terr	migrant	2
Lazuli Bunting	*Passerina amoena*	terr	migrant	1
Blue Grosbeak	*Passerina caerulea*	terr	resident	1
Green-tailed Towhee	*Pipilo chlorurus*	terr	migrant	1
Brewer's Sparrow	*Spizella breweri*	terr	resident	3
Chipping Sparrow	*Spizella passerina*	terr	resident	3
Black-throated Sparrow	*Amphispiza bilineata*	terr	resident	3
Savannah Sparrow	*Passerculus sandwichensis*	terr	migrant	2
White-crowned Sparrow	*Zonotrichia leucophrys*	terr	migrant	6

IVANPAH		Zone	Residency	MNI
Pine Siskin	*Spinus pinus*	terr	migrant	1
House Finch	*Carpodacus mexicanus*	terr	resident	13
Brown-headed Cowbird	*Molothrus ater*	terr	resident	1
Great-tailed Grackle	*Quiscalus mexicanus*	terr	resident	3

Cause of Death of Birds Found at the Solar Power Plants

Photovoltaic facility (Desert Sunlight):

Sixty-one birds from 33 separate species were represented from Desert Sunlight. Due to desiccation and scavenging, a definitive cause of death could not be established for 22 of the 61 birds (see Table 5). Feathers could be examined in all cases, however, and none of the 61 bird remains submitted from the PV facility had visible evidence of feather singeing, a clear contrast with birds found at Ivanpah.

Blunt force impact trauma was determined to have been the cause of death for 19 Desert Sunlight birds including two Western Grebes (*Aechmophorus occidentalis*) and one each of 16 other species. Impact (blunt force) trauma is diagnosed by the presence of fractures and internal and/or external contusions. In particular, bruising around the legs, wings and chest are consistent with crash-landings while fractures of the head and/or neck are consistent with high-velocity, frontal impact (such as may result from impacting a mirror).

Predation was the immediate cause of death for 15 birds. Lesions supporting the finding of predation included decapitation or missing parts of the body with associated hemorrhage (9/15), and lacerations of the skin and pectoral muscles. Eight of the predated birds from Desert Sunlight were

Figure 2: Predation trauma (top) resulting in traumatic amputation of the head and neck (American Avocet) and impact trauma (bottom) causing bruising of the keel ridge of the sternum (Brown Pelican).

grebes, which are unable to easily take off from land. This suggests a link between predation and stranding and/or impact resulting from confusion of the solar panels with water (see Discussion).

Parabolic trough facility (Genesis):

Thirty-one birds were collected from this site. There were 15 species represented. Those found in the greatest numbers were Brown-headed Cowbirds and Cliff Swallows, though no more than 6 individuals from any given species were recovered. Overall, carcass quality was poor and precluded definitive cause of death determination in 17/31 birds (Table 5). Identifiable causes of death consisted of impact trauma (6/31) and predation trauma (2/31). Necropsy findings were similar to those at Desert Sunlight with fractures and hemorrhage noted grossly. Predation trauma was diagnosed in two birds, a Cliff Swallow and a Ring-billed Gull.

Power tower facility (Ivanpah):

Ivanpah is the only facility in this study that produces solar flux, which is intense radiant energy focused by the mirror array on the power-generating tower. Objects that pass through this flux, including insects and birds, encounter extreme heat, although the extent of heating depends on many variables, including the duration of exposure and the precise location in the flux beam.

From Ivanpah, 141 birds were collected and examined. Collection dates spanned a period of one year and five months (July 2012 to December 2013) and included at least seven months of construction during which time the towers were not actively fluxing (2013). There were 49 species represented (Table 4). Those found in the greatest numbers were Yellow-rumped Warblers (*Setophaga coronata;* 14), House Finches (*Carpodacus mexicanus*; 13), Mourning Doves (*Zenaida macroura*; 11) and American Coots (*Fulica americana*; 7). Yellow-rumped Warblers and House Finches were found exclusively at the power tower site.

Solar flux injury was identified as the cause of death in 47/141 birds. Solar flux burns manifested as feather curling, charring, melting and/or breakage and loss. Flight feathers of the tail and/or wings were invariably affected. Burns also tended to occur in one or more of the following areas; the sides of the body (axillae to pelvis), the dorsal coverts, the tops and/sides of the head and neck and the dorsal body wall (the back). Overlapping portions of feathers and light-colored feathers were often spared (Figures 3 and 4).

Figure 3: contour feather from the back of a House Finch with Grade 3 solar flux injury. The feather has curling and charring limited to the exposed tip.

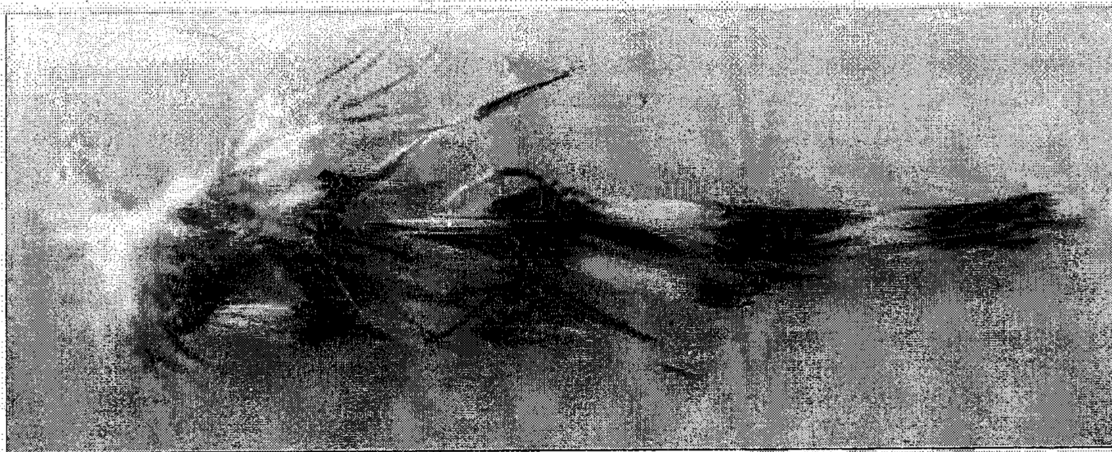


Figure 4: Feather from a Peregrine Falcon with Grade 2 solar flux injury. Note burning of dark feather bands with relative sparing of light bands.

The yellow and red rumps of Yellow-rumped Warblers and House Finches respectively remained strikingly unaffected (See Figure 1). Charring of head feathers, in contrast, was generally diffuse across all color patterns. A pattern of spiraling bands of curled feathers across or around the body and wings was often apparent.

Table 5. Cause of death (COD) data

Cause of Death	Ivanpah	Genesis	Desert Sunlight	Total
Solar Flux	47	0	0	47
Impact trauma	24	6	19	49
Predation trauma	5	2	15	22
Trauma of undetermined cause	14	0	0	14
Electrocution	1	0	0	1
Emaciation	1	0	0	1
Undetermined (remains in poor condition)	46	17	22	85
No evident cause of death	3	6	5	14
Total	141	31	61	233

Eight birds were assigned a feather damage Grade of 1 with curling of less than 50% of the flight feathers. Six of these had other evidence of acute trauma (75%). Five birds were Grade 2, including three birds that were found alive and died shortly afterwards. Of these birds, 2 (the birds found dead) also had evidence of acute trauma. Twenty-eight birds were Grade 3; with charring of body feathers. Of these birds, 21/28

(28%) had other evidence of acute trauma. Remaining carcasses (6) were incomplete and a grade could not be assigned.

Twenty-nine birds with solar flux burns also had evidence of impact trauma. Trauma consisted of skull fractures or indentations (8), sternum fractures (4), one or more rib fractures (4), vertebral fractures (1), leg fracture (3), wing fracture (1) and/or mandible fracture (1). Other signs of trauma included acute macroscopic and/or microscopic internal hemorrhage. Location found was reported for 39 of these birds; most of the intact carcasses were found near or in a tower. One was found in the inner heliostat ring and one was found (alive) on a road between tower sites. The date of carcass collection was provided for 42/47. None were found prior to the reported first flux (2013).

Figure 5: The dorsal aspect of the wing from a Peregrine Falcon (the same bird as shown in Figure 4) with Grade 2 lesions. Note extensive curling of feathers without visible charring. This bird was found alive, unable to fly, emaciated and died shortly thereafter. These findings demonstrate fatal loss of function due to solar flux exposure in the absence of skin or other soft tissue burns.

Among the solar flux cases, a variety of bird species were affected though all but one (a raptor) was a passerine (Appendix 2). House Finches and yellow-rumped Warblers were most often represented (10/47 and 12/47 respectively). For the birds in which species could be determined (41/47), insects were a major dietary component in all but two species. These were an unidentified hummingbird (*Selasphorus*) species (known to include insects in the diet) and a Peregrine Falcon (a species that feeds on small birds).

Four birds were reportedly found alive and taken to a wildlife rehabilitation center where they died one to a few days later (exact dates were not consistently provided). Three had Grade 2 feather burns and one had Grade 3 feather burns. None had other evidence of trauma. Body condition was reduced in all of the birds (two considered thin and two emaciated) based on a paucity of fat stores and depletion of skeletal muscling. The four birds were of four different species and consisted of three passerines and one raptor.

The second most commonly diagnosed cause of death at the Ivanpah facility was impact (or blunt force) trauma (24/141 birds). Necropsy findings were as previously described at the Desert Sunlight facility. Impact marks were reported on heliostat mirrors adjacent to the carcasses in 5 cases and mirrors were described as being vertically-oriented in 5 cases. Specific carcass locations were reported for 18 of the birds. Those birds were found in a variety of areas; below heliostats (8/18), in or near tower and powerblock buildings (4/18), on roads (2/18), below power lines (2/18), in the open (1/18) and by a desert tortoise pen (1/18).

Predation was determined to be the cause of death for five of the birds. A coot and a Mourning Dove were found with extensive trauma and hemorrhage to the head and upper body consisting of lacerations, crush trauma and/or decapitation. One of the birds (an American Coot) was found near a kit fox shelter site. One bird (Northern Mockingbird) was found near the fence line and the third (a Mourning Dove) in an alley way. Two more birds (an unidentified sparrow and an American Pipit) were observed being eaten by one of the resident Common Ravens.

Discussion of Cause of Death of Birds Found at the Solar Power Plants

Impact trauma:

Sheet glass used in commercial and residential buildings has been well-established as a hazard for birds, especially passerines (Klem 1990, 2004, 2006; Loss et al. 2014). A recent comprehensive review estimated that between 365-988 million birds die annually by impacting glass panels in the United States alone (median estimate 599 million; Loss et al. 2014). Conditions that precipitate window strike events include the positioning of vegetation on either side of the glass and the reflective properties of the window. Glass panels that reflect trees and other attractive habitat are involved in a higher number of bird collisions.

The mirrors and photovoltaic panels used at all three facilities are movable and generally directed upwardly, reflecting the sky. At the Ivanpah facility, when heliostats are oriented vertically (typically for washing or installation, personal communication, RAK) they appear to pose a greater risk for birds. Of the eight birds reported found under a heliostat, heliostats were vertically-oriented in at least 5 cases. (D Klem Jr., DC Keck, KL Marty, AJ Miller Ball, EE Niciu, and CT Platt. 2004. Effects of window angling, feeder placement, and scavengers on avian mortality at plate glass. Wilson Bulletin, 116(1):69-73; D Klem Jr. 2006. Glass: A deadly conservation issue for birds. Bird Observer 34(2):73-81; D Klem Jr. 1990.

Collisions between birds and windows: mortality and prevention. Journal of Field Ornithology 61:120–128; Loss, S.R., T. Will, S.S.Loss, and P.P. Marra. 2014. Bird-building collisions in the United States: Estimates of annual mortality and species vulnerability. Condor 116: 8-23). Studies with aquatic insects have found that vertically-oriented black glass surfaces (similar to solar panels) produced highly polarized reflected light, making them highly attractive (Kriska, G., P. Makik, I. Szivak, and G. Horvath. 2008. Glass buildings on river banks as "polarized light traps" for mass-swarming polarotactic caddis flies. Naturwissenschaften 95: 461-467).

A desert environment punctuated by a large expanse of reflective, blue panels may be reminiscent of a large body of water. Birds for which the primary habitat is water, including coots, grebes, and cormorants, were over-represented in mortalities at the Desert Sunlight facility (44%) compared to Genesis (19%) and Ivanpah (10%). Several factors may inform these observations. First, the size and continuity of the panels differs between facilities. Mirrors at Ivanpah are individual, 4 x 8' panels that appear from above as stippling in a desert background (Figure 6). Photovoltaic panels at Desert Sunlight are long banks of adjacent 27.72 x 47.25" panels (70 x 120 cm), providing a more continuous, sky/water appearance. Similarly, troughs at Genesis are banks of 5 x 5.5' panels that are up to 49-65 meters long.

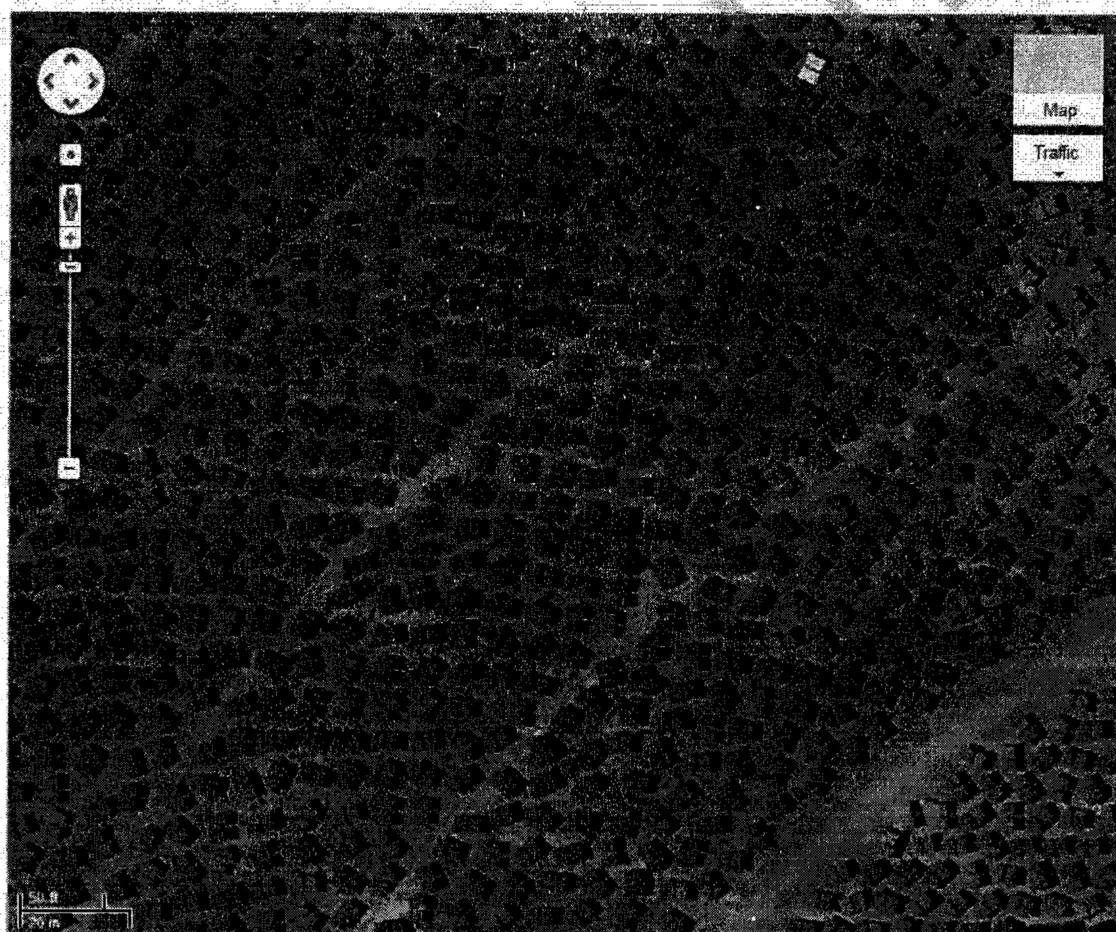


Figure 6: The Ivanpah Solar Electric Generating System as seen via satellite. The mirrored panels are 5 x 8 feet.

There is growing concern about "polarized light pollution" as a source of mortality for wildlife, with evidence that photovoltaic panels may be particularly effective sources of polarized light in the environment (see Horvath et al. 2010. Reducing the maladaptive attractiveness of solar panels to polarotactic insects. Conservation Biology 24: 1644-1653, and ParkScience, Vol. 27, Number 1, 2010; available online at: http://www.nature.nps.gov/parkscience/index.cfm?ArticleID=386&ArticleTypeID=5; as well as discussion of this issue in the Desert Sunlight Final Environmental Impact Statement, Chapter 4, pp. 14-15).

Variables that may affect the illusory characteristics of solar panels are structural elements or markings that may break up the reflection. Visual markers spaced at a distance of 28 cm or less have been shown to reduce the number of window strike events on large commercial buildings (City of Toronto Green Development Standard; Bird-friendly development guidelines. March 2007). Mirrors at the Ivanpah facility are unobscured by structures or markings and present a diffuse, reflective surface. Photovoltaic panels at Desert Sunlight are arranged as large banks of small units that are 60 x 90 cm. The visually uninterrupted expanse of both these types of heliostat is larger than that which provides a solid structure visual cue to passerines. Parabolic troughs at Genesis have large, diffusely reflective surfaces between seams that periodically transect the bank of panels at 5.5' intervals. Structures within the near field, including the linear concentrator and support arms, and their reflection in the panels and may provide a visual cue to differentiate the panel as a solid structure.

The paper by Horvath et al cited above provides experimental evidence that placing a white outline and/or white grid lines on solar panels significantly reduced the attractiveness of these panels to aquatic insects, with a loss of only 1.8% in energy-producing surface area (p. 1651). While similar detailed studies have yet to be carried out with birds, this work, combined with the window strike results, suggest that significant reductions in avian mortality at solar facilities could be achieved by relatively minor modifications of panel and mirror design. This should be a priority for further research.

Finally, ponds are present on the property of the Desert Sunlight and Genesis facilities. The pond at Genesis is netted, reducing access by migratory birds, while the pond at Desert Sunlight is open to flighted wildlife. Thus, birds are both attracted to the water feature at Desert Sunlight and habituated to the presence of an accessible aquatic environment in the area. This may translate into the misinterpretation of a diffusely reflected sky or horizonal polarized light source as a body of water.

Stranding and Predation:

Predation is likely linked to panel-related impact trauma and stranding. Water birds were heavily over-represented in predation mortalities at Desert Sunlight. Of the 15 birds that died due to predation, 14 make their primary habitat on water (coots, grebes, a cormorant, and an avocet). A single White-winged Dove was the only terrestrial-based predation mortality in the submitted specimens. This is in contrast to blunt trauma mortalities at Desert Sunlight in which 8 of the 19 birds determined to have died of impact trauma were water species.

Locations of the birds when found dead were noted on several submissions. Of the birds that died of predation for which locations were known, none were located near ponds. The physiology of several of these water birds is such that locomotion on land is difficult or impossible. Grebes in particular have very limited mobility on land and require a run across water in order to take off (Jehl, J. R., 1996. Mass mortality events of Eared Grebes in North America. Journal of Field Ornithology 67: 471-476). Thus, these birds likely did not reach their final location intentionally. Ponds at the PV and trough sites are fenced, prohibiting terrestrial access by predators. Birds on the water or banks of the pond are inaccessible to resident predators. Therefore, it is unlikely that the birds were captured at the pond and transported by a predator into the area of the panels. Attempts to land or feed on the panels because of their deceptive appearance may have injured the birds to the point that they could not escape to safety, or inadvertently stranded the birds on a substrate from which they could not take flight. We believe that an inability to quickly flee after striking the panels and stranding on the ground left these birds vulnerable to opportunistic predators. At least two types of predators, kit foxes and ravens, have been observed in residence at the power tower and PV facilities and ravens have been reported at the trough site (personal communication and observation, RAK). Additionally, histories for multiple birds found at the tower site document carcasses found near kit fox shelters or being eaten or carried by a raven.

Solar Flux:

Avian mortality due to exposure to solar flux has been previously explored and documented (McCrary, M. D., McKernan, R. L., Schreiber, R. W., Wagner, W. D., and Sciarrotta, T. C. Avian mortality at a solar energy power plant. Journal of Field Ornithology, 57(2): 135-141). Solar flux injury to the birds of this report, as expected, occurred only at the power tower facility. Flux injury grossly differed from other sources of heat injury, such as electrocution or fire. Electrocution injury requires the bridging of two contact points and is, therefore, seen almost exclusively in larger birds such as raptors. Contact points tend to be on the feet, carpi and/or head and burns are often found in these areas. Electrocution causes deep tissue damage as opposed to the surface damage of fire or solar flux. Other sequelae include amputation of limbs with burn marks on bone, blood vessel tears and pericardial hemorrhage. Burns from fires cause widespread charring and melting of feathers and soft tissues and histopathologic findings of soot inhalation or heat damage to the respiratory mucosa. None of these were characteristics of flux injury. In the flux cases small birds were over-represented, had burns generally limited to the feathers and internal injuries attributable to impact. Flux injury inconsistently resulted in charring, tended to affect feathers along the dorsal aspects of the wings and tail, and formed band-like patterns across the body (Divincenti, F. C., J. A. Moncrief, and B. A. Pruitt. 1969. Electrical injuries: a review of 65 cases. The Journal of Trauma 9: 497-507).

Proposed mechanisms of solar flux-related death follow one or a combination of the following pathways:

- impact trauma following direct heat damage to feathers and subsequent loss of flight ability
- starvation and/or thermoregulatory dysfunction following direct heat damage to feathers
- shock
- soft tissue damage following whole-body exposure to high heat
- ocular damage following exposure to bright light.

Necropsy findings from this study are most supportive of the first three mechanisms.

Loss of feather integrity has effects on a bird's ability to take off, land, sustain flight and maneuver. Tail feathers are needed for lift production and maneuverability, remiges are needed for thrust and lift and feathers along the propatagium and coverts confer smoothness to the avian airfoil. Shortening of primary flight feathers by as little as 1.6 cm with loss of secondary and tertiary remiges has been shown to eliminate take-off ability in house sparrows further demonstrating the importance of these feathers (Brown, R. E., and A. C. Cogley, 1996. Contributions of the propatagium to avian flight: Journal of Experimental Zoology 276: 112-124). Loss of relatively few flight feathers can, therefore, render a bird unable or poorly-able to fly. Birds encountering the flux field at Ivanpah may fall as far as 400 feet after feather singeing. Signs of impact trauma were often observed in birds with feather burns and are supportive of sudden loss of function (Beaufrere, H., 2009. A review of biomechanic and aerodynamic considerations of the avian thoracic limb. Journal of Avian Medicine and Surgery 23: 173-185).

Birds appear to be able to survive flux burns in the short term, as evidenced by the collection of several live birds with singed feathers. Additionally, Forensic Lab staff observed a falcon or falcon-like bird with a plume of smoke arising from the tail as it passed through the flux field. Immediately after encountering the flux, the bird exhibited a controlled loss of stability and altitude but was able to cross the perimeter fence before landing. The bird could not be further located following a brief search (personal observation, RAK and EOE). Birds that initially survive the flux exposure and are able to glide to the ground or a perch may be disabled to the point that they cannot efficiently acquire food, escape predators or thermoregulate. Observations of emaciation in association with feather burns in birds found alive is supportive of debilitation subsequent to flux exposure. More observational studies and follow-up are required to understand how many birds survive flux exposure and whether survival is always merely short-term. As demonstrated by the falcon, injured birds (particulary larger birds), may be ambulatory enough to glide or walk over the property line indicating a need to include adjacent land in carcass searches.

There was evidence of acute skin burns on the heads of some of the Grade 3 birds that were found dead. But interestingly, tissue burn effects could not be demonstrated in birds known to have survived short periods after being burned. Hyperthermia causing instantaneous death manifests as rapid burning of tissue, but when death occurs a day or later there will be signs of tissue loss, inflammation, proteinic exudate and/or cellular death leading to multisystemic organ failure. The beginnings of an inflammatory response to injury can be microscopically observed within one to a few hours after the insult and would have been expected in any of the four birds found alive. Signs of heat stroke or inhalation of hot air should have been observable a day or more after the incident. Rather, in these cases extensive feather burns on the body largely appeared to be limited to the tips of the feathers with the overlapping portions insulating the body as designed. This, in conjunction with what is likely only a few seconds or less spent in the flux, suggests that skin or internal organ damage from exposure to high temperatures in solar flux may not be a major cause of the observed mortality.

Ocular damage following light exposure was also considered but could not be demonstrated in the submitted birds. In the four birds that initially survived, there were no signs of retinal damage, inflammation or other ocular trauma. Given the small sample size, this does not preclude sight impairment as a possible sequela but clinical monitoring of survivors would be needed to draw more definitive conclusions.

Other/Undetermined:

Powerline electrocution was the cause of death for one bird (a juvenile Common Raven) at the Ivanpah facility. Electrocution at these solar facilities is a potential hazard but, thus far, appears to be an uncommon cause of death.

Smashed birds (13/233) were found at all three locations. Detailed carcass collection information was provided for 6; all were found on roads. Though poor carcass quality in all cases precluded definitive cause death determination, circumstances and carcass condition suggest vehicle trauma as the cause of deaths. The relatively low numbers of vehicle collisions may be attributed to slow on-site vehicle speeds and light traffic. Vehicle collisions, therefore, do not appear to be a major source of mortality and would be expected to decrease as construction ends.

There was a large number of birds (85/233) for which a cause of death could not be determined due to poor carcass condition. The arid, hot environment at these facilities leads to rapid carcass degradation which greatly hinders pathology examination. Results were especially poor for birds from the Genesis facility, where the cause of death(s) for 23/31 (74%) could not be determined. These results underscore the need for carcasses to be collected soon after death. More frequent, concerted carcass sweeps are advised.

Insect mortality and solar facilities as "mega-traps"

An ecological trap is a situation that results in an animal selecting a habitat that reduces its fitness relative to other available habitats (Robertson, B.A. and R.L. Hutto. 2006. A framework for understanding ecological traps and an evaluation of existing evidence. Ecology 87: 1075-1085; Robertson, B.A., J.S. Rehage, and Sih, A. 2013. Ecological novelty and the emergence of evolutionary traps. Trends in Ecology and Evolution 28: 552-560).

A wide variety of circumstances may create ecological traps, ranging from subtle (songbirds attracted to food resources in city parks, where they are vulnerable to unnaturally high populations of predators) to direct (birds are attracted to oil-filled ponds, believing it to be water, and become trapped). It appears that solar flux facilities may act as **"mega-traps,"** which we define as artificial features that attract and kill species of multiple trophic layers. The strong light emitted by these facilities attract insects, which in turn attract insect-eating birds, which are incapacitated by solar flux injury, thus attracting predators and creating an entire food chain vulnerable to injury and death.

OLE staff observed large numbers of insect carcasses throughout the Ivanpah site during their visit. In some places there were hundreds upon hundreds of butterflies (including monarchs, *Danaus plexippus*) and dragonfly carcasses. Some showed singeing, and many appeared to have just fallen from the sky. Careful observation with binoculars showed the insects were active in the bright area around the boiler at the top of the tower. It was deduced that the solar flux creates such a bright light that it is brighter than the surrounding daylight. Insects were attracted to the light and could be seen actively flying the height of the tower. Birds were also observed feeding on the insects. At times birds flew into the solar flux and ignited. Bird carcasses recovered from the site showed the typical singed feathers. The large populations of insects may also attract indigenous bat species, which were seen roosting in structures at the base of the power tower.

Monarch butterflies in North America – both east and west of the Rocky Mountains – have been documented to be in decline (see the North American Monarch Conservation Plan, available at: http://www.mlmp.org/Resources/pdf/5431_Monarch_en.pdf). Proposed causes include general habitat loss and specific loss of milkweed, upon which the butterflies feed and reproduce. Considering the numerous monarch butterfly carcasses seen at the Ivanpah facility, it appears that solar power towers could have a significant impact on monarch populations in the desert southwest. Analysis of the insect mortality at Ivanpah, and systematic observations of bird/insect interactions around the power tower, is clearly needed.

Bird species affected by solar flux include both insectivores (e.g. swallows, swifts, flycatchers, and warblers) and raptors that prey on insect-feeding birds. Based on observations of the tower in flux and the finding of large numbers of butterflies, dragonflies and other insects at the base of the tower and in adjacent buildings it is suspected that the bright light generated by solar flux attracts insects, which in turn attracts insectivores and predators of insectivores. Waterbirds and other birds that feed on vegetation were not found to have solar flux burns. Birds were observed perching and feeding on railings at the top of the tower, apparently in response to the insect aggregations there.

Further, dead bats found at the Ivanpah site could be attracted to the large numbers of insects in the area. Nineteen bats from the condenser area of the power tower facility have been submitted to NFWFL for further evaluation. These bats belong to the Vespertilionidae and Molossidae families, which contain species considered by the Bureau of Land Management to be sensitive species in California. Preliminary evaluation revealed no apparent singing of the hair, and analysis is ongoing.

Solar flux and heat associated with solar power tower facilities

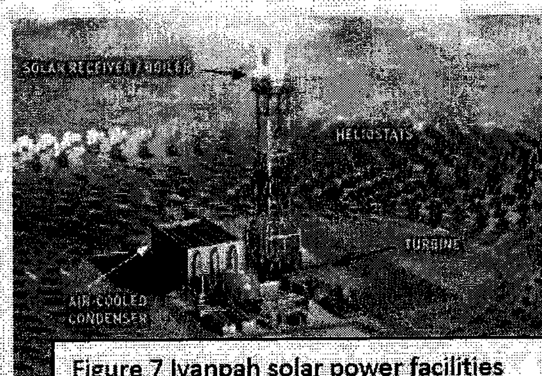


Figure 7 Ivanpah solar power facilities http://ivanpahsolar.com/about

Despite repeated requests, we have been unsuccessful in obtaining technical data relating to the temperature associated with solar flux at the Ivanpah facility. The following summarizes the information we have gathered from other sources.

The Ivanpah solar energy generating facility consists of mirrors that reflect sunlight to a tower. In the tower sits a boiler that generates steam which then powers a turbine.

At the top of a 459 foot tall tower sits a boiler (solar receiver) that is heated by the sun rays reflected by 300,000 mirrors, called solar heliostats. When the concentrated sunlight strikes the boiler tubes, it heats the water to create superheated steam. The high temperature steam is then piped from the boiler to a turbine where electricity is generated (http://ivanpahsolar.com/about visited on 01/20/2014).

If all the solar heliostats are focused on the solar tower the beams multiply the strength of sunlight by 5000 times, and this generates temperatures at the solar tower in excess of 3600° Fahrenheit (> 1982° Celsius). Since steel melts at 2750° Fahrenheit (1510° Celsius), only a percentage of heliostats are focused on the solar receiver so that) the optimal temperature at the tower is approximately 900° Fahrenheit (~482° Celsius) ("How do they do it" Wag TV for Discovery Channel, Season 3, Episode 15, "Design Airplane Parachutes, Create Solar Power, Make Sunglasses" Aired August 25, 2009).

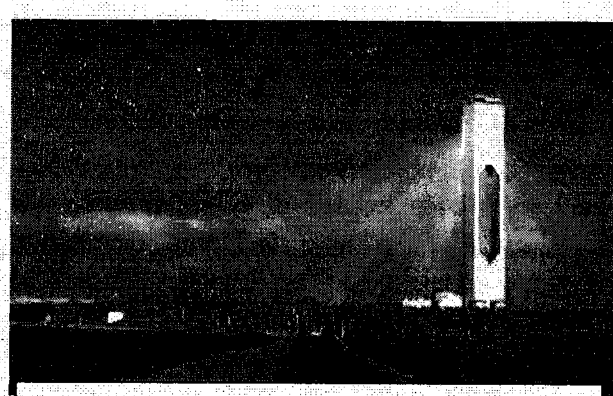


Figure 8: Seville solar power facility (http://inhabitat.com/sevilles-solar-power-tower)

A solar steam plant in Coalinga that also uses heliostat technology for extracting oil is on record stating that the steam generator is set to about 500° Celsius. (http://abclocal.go.com/kDSn/story?section=news%2Fbusiness&id=8377469 Viewed Jan 21, 2013)

Temperatures measured by the authors at the edge of the solar complex on the surface of a heliostat were approximately 200° Fahrenheit (~93° Celsius). Therefore, there is a gradient of temperature from the edge of the solar field to the tower that ranges from 200° to 900° Fahrenheit.

There is a phenomenon that occurs when the heliostats are focused on the tower and electricity is being generated. The phenomenon can be described as either a circle of clouds around the tower or, at times, a cloud formed on the side that is receiving the solar reflection. It appears as though the tower is creating clouds. Currently we propose two hypotheses of why this "cloud" is formed. The first hypothesis is simply the presumption that the high heat associated with towers is condensing the air, and forming the

Figure 9: Tower 1 (bright white) is shown under power. Tower 2 (black) is not operating.

clouds. The second hypothesis is that this phenomenon does not represent clouds at all rather it is a place in space where the heliostats that are not being used to generate heat are focused. Under this scenario, it is a place where the mirrors focus the excess energy not being used to generate electricity.

Ivanpah employees and OLE staff noticed that close to the periphery of the tower and within the reflected solar field area, streams of smoke rise when an object crosses the solar flux fields aimed at the tower. Ivanpah employees used the term "streamers" to characterize this occurrence.

When OLE staff visited the Ivanpah Solar plant, we observed many streamer events. It is claimed that these events represent the combustion of loose debris, or insects. Although some of the events are likely that, there were instances in which the amount of smoke produced by the ignition could only be explained by a larger flammable biomass such as a bird. Indeed OLE staff observed birds entering the solar flux and igniting, consequently becoming a streamer.

OLE staff observed an average of one streamer event every two minutes. It appeared that the streamer events occurred more frequently within the "cloud" area adjacent to the tower. Therefore we hypothesize that the "cloud" has a very high temperature that is igniting all material that traverses its field.
One possible explanation of this this phenomenon is that the "cloud" is a convergent location where heliostats are "parked" when not in use. Conversely it undermines the condensation hypothesis, given that birds flying through condensation clouds will not spontaneously ignite.

Temperatures required to burn feathers

Many of the carcasses recovered from the Ivanpah Solar plant after the plant became operational showed singing of feathers as shown in Figure 10.

Figure 10: Singed feathers from a Northern Rough-winged Swallow

In order to investigate at what temperature feathers burn/singe, we exposed feathers to different air temperatures. Each feather was exposed to a stream of helium and air for 30 seconds. The results indicate that at 400° Celsius (752° Fahrenheit) after 30 seconds the feather begins to degrade. But at 450° and

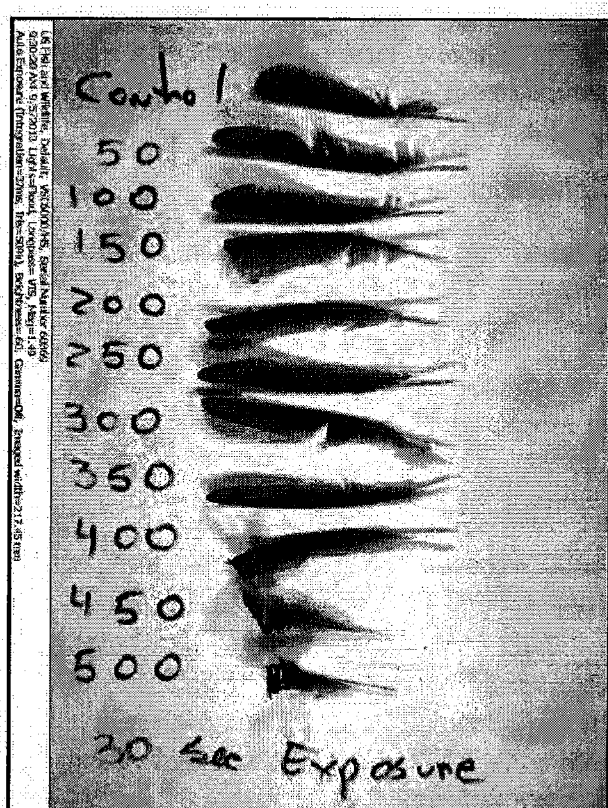


Figure 11: Results of exposing feathers to different temperatures (in degrees Celsius)

500° Celsius (842° and 932° Fahrenheit respectively) the feathers singed as soon as they made contact with the superheated air (Figure 11). Therefore, when singed birds are found, it can be inferred that the temperatures in the solar flux at the time a bird flew through it was at least 400° Celsius (752° Fahrenheit). This inference is consistent with the desired operating temperature of a power tower solar boiler (482° Celsius).

The fact that a bird will catch on fire as it flies through the solar flux has been confirmed by a Chevron engineer who works at the Coalinga Chevron Steam plant, a joint venture of Chevron and BrightSource Solar. (http://abclocal.go.com/kDSn/story?section=news%2Fbusiness&id=8377469 Viewed Jan 21, 2013)

Conclusions and Recommendations

In summary, three main causes of avian mortality were identified at these facilities; impact trauma, predation and solar flux. Birds at all three types of solar plants were susceptible to impact trauma and predators. Solar flux injury was unique to the power tower facility. Solar facilities, in general, do not appear to attract particular species, rather an ecological variety of birds are vulnerable. That said, certain mortality and species trends were evident, such as waterbirds at Desert Sunlight, where open water sources were present.

Specific hazards were identified, including vertically-oriented mirrors or other smooth reflective panels; water-like reflective or polarizing panels; actively fluxing towers; open bodies of water; aggregations of insects that attracted insectivorous birds; and resident predators. Making towers, ponds and panels less attractive or accessible to birds may mitigate deaths. Specific actions include placing perch-guards on power tower railings near the flux field, properly netting or otherwise covering ponds, tilting heliostat mirrors during washing and suspending power tower operation at peak migration times.

Visual cues should be retrofitted to existing panels and incorporated into new panel design. These cues may include UV-reflective or solid, contrasting bands spaced no further than 28 cm from each other. This arrangement has been shown to significantly reduce the number of passerines hitting expanses of windows on commercial buildings. Spacing of 10 cm eliminates window strikes altogether. Further exploration of panel design and orientation should be undertaken with researchers experienced in the field (Daneil Klem Jr. of Muhlenberg College) to determine causes for the high rate of impact trauma, and designs optimized to reduce these mortalities.

Challenges to data collection included rapid degradation of carcass quality hindering cause of death and species determination; large facilities which are difficult to efficiently search for carcasses; vegetation and panels obscuring ground visibility; carcass loss due to scavenging; and inconsistent documentation of carcass history. Searcher efficiency has been shown to have varying influences on carcass recovery with anywhere from 30% to 90% detection of small birds achieved in studies done at wind plants (Erickson et al., 2005). Scavengers may also remove substantial numbers of carcasses. In studies done on agricultural fields, up to 90% of small bird carcasses were lost within 24 hours (Balcomb, 1986; Wobeser and Wobeser, 1992). OLE staff observed apparently resident ravens at the Ivanpah power tower. Ravens are efficient scavengers, and could remove large numbers of small bird carcasses from the tower vicinity. (Erickson, W. P., G. D. Johnson, and D. P. Young, Jr., 2005, A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions: U S Forest Service General Technical Report PSW, v. 191, p. 1029-1042; Balcomb, R., 1986, Songbird carcasses disappear rapidly from agricultural fields: Auk, v. 103, p. 817-820; Wobeser, G., and A. G. Wobeser, 1992, Carcass disappearance and estimation of mortality in a simulated die-off of small birds: Journal of Wildlife Diseases, v. 28, p. 548-554.)

Given these variables it is difficult to know the true scope of avian mortality at these facilities. The numbers of dead birds are likely underrepresented, perhaps vastly so. Observational and statistical studies to account for carcass loss may help us to gain a better sense of how many birds are being killed. Complete histories would help us to identify factors (such as vertical placement of mirrors) leading to mortalities. Continued monitoring is also advised as these facilities transition from construction to full operation. Of especial concern is the Ivanpah facility which was not fully-functioning at the time of the latest carcass submissions. In fact, all but 7 of the carcasses with solar flux injury and reported dates of collection were found at or prior to the USFWS site visit (October 21-24, 2013) and, therefore, represent flux mortality from a facility operating at only 33% capacity. Investigation into bat and insect mortalities at the power tower site should also be pursued.

ACKNOWLEDGMENTS

We wish to acknowledge the invaluable assistance and insights of S.A. Michael Clark and S.A. Ed Nieves.

Appendix 1. List of all 71 species recovered from the three solar energy sites. In this table, remains of closely related taxa that could not be definitively identified (e.g. Cinnamon/Blue-winged Teal and Black-throated/Sage Sparrow) are assigned to the biogeographically more likely taxon. In all such cases, the possible taxa are ecologically similar. All of these species are MBTA-listed.

SPECIES		Zone	Residency	Sites	MNI
Cinnamon Teal	*Anas cyanoptera*	water	migrant	DS,IV	5
Pied-billed Grebe	*Podilymbus podiceps*	water	migrant	DS	1
Western Grebe	*Aechmorphorus occidentalis*	water	migrant	DS	9
Eared Grebe	*Podiceps nigricollis*	water	migrant	DS,GN	5
Brown Pelican	*Pelecanus occidentalis*	water	migrant	DS	2
Double-crested Cormorant	*Phalacrocorax auritus*	water	migrant	DS	2
Great Blue Heron	*Ardea herodias*	water	migrant	GN	1
Black-crowned Night-Heron	*Nycticorax nycticorax*	water	migrant	DS	1
Cooper's Hawk	*Accipiter cooperii*	air	migrant	IV	1
Red-shouldered Hawk	*Buteo lineatus*	terr	migrant	IV	1
American Kestrel	*Falco sparverius*	air	resident	GN,IV	2
Peregrine Falcon	*Falco peregrinus*	air	resident	IV	1
American Coot	*Fulica americana*	water	migrant	DS; IV	12
Yuma Clapper Rail	*Rallus longirostris yumanensis*	water	resident	DS	1
Sora	*Porzana carolina*	water	migrant	DS,IV	2
American Avocet	*Recurvirostra americana*	water	migrant	DS	1
Spotted Sandpiper	*Actitis maculatus*	water	migrant	IV	2
Ring-billed Gull	*Larus delawarensis*	water	migrant	GN	2
California Gull	*Larus californianus*	water	resident	GN	1
Greater Roadrunner	*Geococcyx californianus*	terr	resident	IV	5
Yellow-billed Cuckoo	*Coccyzus americanus*	terr	migrant	IV	1
Mourning Dove	*Zenaida macroura*	terr	resident	DS, IV	14
White-winged Dove	*Zenaida asiatica*	terr	resident	DS,GN	2
Barn Owl	*Tyto alba*	terr	resident	IV	1
Lesser nighthawk	*Chordeiles acutipennis*	air	resident	DS,GN,IV	7
Common Poorwill	*Phalaenoptilus nuttallii*	air	resident	DS,IV	2
White-throated Swift	*Aeronautes saxatalis*	air	resident	IV	1
Costa's Hummingbird	*Calypte costae*	air	resident	DS	1
Allen's/Rufous Hummingbird	*Selasphorus sp.*	air	migrant	IV	1
Northern Flicker	*Colaptes auratus*	terr	resident	IV	1
Ash-throated Flycatcher	*Myiarchus cinerascens*	air	resident	DS,IV	2
Say's Phoebe	*Sayornis saya*	air	resident	GN	2
Black Phoebe	*Sayornis nigricollis*	air	resident	DS	1
Loggerhead shrike	*Lanius ludovicianus*	terr	resident	DS,IV	5
Warbling Vireo	*Vireo gilvus*	terr	migrant	IV	1
Common Raven	*Corvus corax*	terr	resident	DS,IV	3
Horned Lark	*Eremophila alpestris*	terr	migrant	DS	1
Tree Swallow	*Tachycineta bicolor*	air	migrant	DS,GN,IV	5

SPECIES		Zone	Residency	Sites	MNI
Cliff Swallow	*Petrochelidon pyrrhonota*	air	resident	GN	5
No. Rough-winged Swallow	*Stelgidopteryx serripennis*	air	migrant	IV	2
Verdin	*Auriparus flaviceps*	terr	resident	IV	3
Blue-gray Gnatcatcher	*Polioptila caerulea*	terr	resident	IV	1
Northern Mockingbird	*Mimus polyglottos*	terr	resident	IV	1
American Pipit	*Anthus rubescens*	terr	migrant	IV	4
Orange-crowned Warbler	*Oreothlypis celata*	terr	migrant	IV	1
Lucy's Warbler	*Oreothlypis luciae*	terr	resident	IV	1
Yellow-rumped Warbler	*Setophaga coronata*	air	migrant	IV	14
Black-throated Gray Warbler	*Setophaga nigrescens*	terr	migrant	IV	1
Hermit Warbler	*Setophaga occidentalis*	terr	migrant	GN	1
Townsend's warbler	*Setophaga townsendi*	terr	migrant	DS,IV	4
Yellow Warbler	*Setophaga petechia*	terr	migrant	IV	1
Black-and-white Warbler	*Mniotilta varia*	terr	migrant	IV	1
MacGillivray's Warbler	*Oporornis tolmei*	terr	migrant	IV	1
Wilson's Warbler	*Cardellina pusilla*	terr	migrant	DS,IV	4
Common Yellowthroat	*Geothlypis trichas*	terr	migrant	DS	1
Western Tanager	*Piranga ludoviciana*	terr	migrant	DS,IV	4
Black-headed Grosbeak	*Pheucticus melanocephalus*	terr	migrant	DS,GN	2
Lazuli Bunting	*Passerina caerulea*	terr	migrant	IV	1
Blue Grosbeak	*Passerina caerulea*	terr	resident	IV	1
Green-tailed Towhee	*Pipilo chlorurus*	terr	migrant	IV	1
Brewer's Sparrow	*Spizella breweri*	terr	resident	IV	3
Chipping Sparrow	*Spizella passerina*	terr	resident	GN,IV	4
Black-throated Sparrow	*Amphispiza bilineata*	terr	resident	DS,IV	4
Savannah Sparrow	*Passerculus sandwichensis*	terr	migrant	DS,IV	3
White-crowned Sparrow	*Zonotrichia leucophrys*	terr	migrant	IV	6
Pine Siskin	*Spinus pinus*	terr	migrant	IV	1
House Finch	*Carpodacus mexicanus*	terr	resident	IV	13
Great-tailed Grackle	*Quiscalus mexicanus*	terr	resident	DS,IV	5
Brown-headed Cowbird	*Molothrus ater*	terr	resident	DS,GN,IV	8
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	terr	migrant	DS	1
Bullock's Oriole	*Icterus bullockii*	terr	resident	GN	2

Species recovered from one site: 47
two sites: 18
three sites: 5

Appendix 2. Species with solar flux burns

Common Name	Scientific name	
Yellow-rumped warbler	*Setophaga coronata*	12
House finch	*Carpodacus mexicanus*	10
Chipping sparrow	*Spizella passerina*	2
Unidentified warbler	*Parulidae*	2
Verdin	*Auriparus flaviceps*	2
Great-tailed grackle	*Quiscalus mexicanus*	2
Lucy's warbler	*Oreothlypis luciae*	1
Wilson's warbler	*Cardellina pusilla*	1
MacGillivray's warbler	*Oporornis tolmei*	1
Black-throated gray warbler	*Setophaga nigrescens*	1
Townsend's warbler	*Setophaga townsendi*	1
Orange-crowned warbler	*Oreothlypis celata*	1
Blue-gray gnatcatcher	*Polioptila caerulea*	1
Unidentified swallow	*Hirundinidae*	1
Northern rough-winged swallow	*Stelgidopteryx serripennis*	1
Warbling vireo	*Vireo gilvus*	1
Unidentified hummingbird	*Selasphorus sp.*	1
Unidentified passerine	Passeriformes	1
Unidentified finch	*Carpodacus sp.*	1
Lazuli bunting	*Passerina caerulea*	1
Unidentified sparrow	*Spizella species*	1
Unidentified blackbird	*Icteridae*	1
Peregrine falcon	*Falco peregrinus*	1