Staring at the Sun: What's Obstructing the Vision of a Solar-Thermal Powered Future?

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Introduction

According to ancient writings, Greek inventor Archimedes used a series of mirrors to concentrate and reflect sunlight in order to set fire to Marcellus' Roman fleet besieging the city of Syracuse in 212 B.C.[1] In 2010, the *Mythbusters* television show came to the conclusion that, while it is theoretically possible to set fire to a ship this way, it is unlikely this technique would have been successful in a fast moving battle.[2] Today, however, a modern application of this ancient technology, concentrating solar power (CSP), sometimes called solar-thermal, has the potential to help us meet national and local sustainability goals by harnessing the sun's energy to generate electricity.[3]

Unlike photovoltaic cell technology (PV), in which solar energy is converted directly into electrical energy using semiconductor materials in solar panels, CSP uses mirrors to concentrate and redirect solar energy in order to heat a fluid that generates steam to turn a turbine.[4] CSP plants operate much like traditional fossil fuel-based power plants but use the sun for fuel and, thus, emit no carbon dioxide.[5] There are four distinct types of CSP plants currently in use: parabolic trough, linear Fresnel, power tower, and dish/engine.[6] One major advantage that the first three types of CSP technology currently have over PV is their ability to store thermal energy

[1] D.L. Simms, *Archimedes and the Burning Mirrors of Syracuse*, 18 TECHNOLOGY AND CULTURE 1 (Jan. 1977), *available at* http://www.jstor.org/stable/3103202.
[2] *Archimedes and the Burning Mirror*, UNMUSEUM.ORG, http://www.unmuseum.org/burning_mirror.htm (last viewed Jan. 7, 2014).
[3] *See* Sean Pool & John Dos Passos Coggin, *Fulfilling the Promise of Concentrating Solar Power*, CTR. FOR AMERICAN PROGRESS 3 (June 2013), *available at* http://www.americanprogress.org/wp-content/uploads/2013/06/PoolSolarPower-report-3.pdf.
[4] L. William Staudenmaier, *Water Requirements for Utility-Scale Concentrating Solar Power Facilities: Are We Robbing Peter to Pay Paul?*, 25 NAT. RESOURCES & ENV'T 38, 39 (2011).
[5] *Id*.
[6] Robert Glennon & Andrew M. Reeves, *Solar Energy's Cloudy Future*, 1 ARIZ. J. ENVTL. L. & POL'Y 91, 97 (2010).

collected during the day for conversion at night.[7] This means that their production profile can match the demand profile, potentially providing base load power to utilities twenty-four hours per day.[8]

On October 9, 2013, Abengoa Solar's 280-megawatt "Solana" plant in Arizona began commercial operations.[9] Combining parabolic trough mirror technology with molten salt thermal storage,[10] the Solana plant is the largest CSP plant of its kind in the world.[11] The plant's ability to store heat energy using molten salt is seen as a "transformational breakthrough in utility scale solar power" since it provides power generation long after the sun goes down.[12] Under a Power Purchase Agreement (PPA), the Arizona Public Service will buy all of the electricity that the plant produces for the next thirty years.[13]

In late 2013, the "Ivanpah" power tower CSP plant, located in the Mohave Desert of California, is slated for completion.[14] This plant, co-owned by BrightSource, NRG, and Google, will be the largest CSP plant of any kind in the world.[15] It is powered by a system of software-controlled mirrors, or "heliostats," that follow the sun and reflect it onto a boiler filled with water situated atop a 450ft tall tower.[16] Unlike the Solana plant, however, it does not currently have

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[7] Romeu Gaspar, *How Solar PV is Winning Over CSP*, RENEWABLEENERGYWORLD.COM (March 12, 2013), *available at* http://www.renewableenergyworld.com/rea/blog/post/2013/03/how-solar-pv-is-winning-over-csp.
[8] *Id*.
[9] Chris Clark, *Solar Plant Generates Power for Six Hours after Sunset*, KCET (October 11, 2013, 12:07 PM), *available at* http://www.kcet.org/news/rewire/solar/concentrating-solar/solar-plant-generates-power-for-six-hours-after-sunset.html.
[10] *Id*.
[11] Tina Casey, *Abengoa's Gigantic 'Salt Battery' Stores Utility Scale Solar Energy*, TRIPLEPUNDIT (October 9, 2013), *available at* http://www.triplepundit.com/2013/10/arizona-solar-power-sector-leaps-into-us-lead-with-new-plant/.
[12] *Id*.
[13] *Id*.; Clark *supra* note 9.
[14] *NRG Energy, Inc. (BrightSource)*, DEPT. OF ENERGY LOAN PROGRAMS OFFICE, http://lpo.energy.gov/?projects=brightsource-energy-inc (last viewed Jan. 7, 2014).
[15] *Id*.
[16] *Id*.

thermal storage capabilities.[17] When operational, Ivanpah will generate 392 mega-watts of electricity, enough to power nearly 100,000 homes.[18] Plants like this will be essential to California meeting its renewable energy goals.[19]

In order for CSP's potential to be unleashed, creative political and legislative solutions are needed to meet the various challenges facing the industry.[20] Federal financial incentives can play a huge role in minimizing some of the uncertainty inherent in large-scale renewable energy projects.[21] Similarly, continued investment in research and development as well as the implementation of market-based policy adjustments can help to ensure that CSP will be competitive with traditional forms of power generation.[22] Finally, a delicate balancing act of opposing environmental policy concerns regarding the use of finite water and land resources is necessary to make breaking ground on new CSP projects possible.[23] In order to face this diverse array of economic and environmental challenges, federal and state governments are working together with the scientific community, environmental groups, and private enterprise to come up with innovative policy-based solutions.[24]

The Stimulus Effect

There is little doubt that generous subsidies and loan guarantees authorized by the 2009 American Recovery and Reinvestment Act (ARRA) added much needed momentum to the solar power industry.[25] Originally, the government offered a thirty percent investment tax credit to

[17] Clark *supra* note 9.
[18] *Id.*
[19] Glennon *supra* note 6, at 107, Table 3.
[20] *Id*. at 294–297.
[21] *Id*. at 373.
[22] *See* Pool *supra* note 3, at 1.
[23] *See* Glennon *supra* note 6.
[24] *See* Pool *supra* note 3, at 1.
[25] Glennon *supra* note 6, at 91.

developers starting new solar projects.[26] However, because of the lack of private investment due to the recession, the Administration began offering construction grants of up to thirty-percent of the project's total cost instead.[27] In addition to these payments, the ARRA incentivized banks to loan money for utility-scale solar projects through the Department of Energy's Loan Guarantee Program.[28] Plants such as Solana and Ivanpah took advantage of these ARRA grants and loan guarantees before both programs were discontinued in 2011.[29] Although the federal government still offers investment tax credits and accelerated depreciation, new CSP projects must now find their funding in uncertain financial markets.[30]

Competing with Traditional Energy Sources

One of the biggest concerns regarding CSP technology, as with all sources of renewable energy, is its ability to compete with traditional energy sources.[31] The Ivanpah and Solana plants are projected to generate electricity at around 14 cents per kilowatt-hour.[32] Compared with the Tucson Electric Power Company's coal-fired plant that produces at around 4 cents per kilowatt-hour and the Palo Verde Nuclear Generating Station that produces at 1.65 cents per kilowatt-hour, CSP still has a long way to go. The Obama administration's SunShot Initiative has set a goal to "decrease the total costs of solar energy systems by 75%, which will lead to the rapid, wide-scale adoption of this clean, renewable energy."[33] Meeting this goal would decrease the price of solar energy to 6 cents per kilowatt-hour and "enable solar-generated power to account

[26] Janine Blaeloch, *Government Subsidies for Industrial-Scale Solar*, SOLAR DONE RIGHT (December 12, 2011), *available at* http://solardoneright.org/index.php/briefings/post.
[27] *Id*.
[28] Daniel K. Tracey, *The Missing Lending Link: Why A Federal Loan Guarantee Program Is Critical to the Continued Growth of the Solar Power Industry*, 16 N.C. BANKING INST. 349, 350 (2012).
[29] *Id*.; Glennon *supra* note 6, at 135.
[30] Tracy, *supra* note 28, at 355.
[31] *See generally* Glennon *supra* note 6.
[32] *See* Chris Meehan, *Massive CSP projects finally coming online in CA, AZ*, CLEANENERGY AUTHORITY (July 31, 2013), *available at* http://www.cleanenergyauthority.com/solar-energy-news/massive-csp-projects-073113.
[33] *SunShot Initiative: Concentrating Solar Power*, DEPT. OF ENERGY, http://www1.eere.energy.gov/solar/sunshot/csp.html (last updated Nov. 20, 2013).

for 15-18% of America's electricity generation by 2030."[34] To achieve their objective, the Department of Energy is funding research and development projects and loan guarantees for high-value concepts that promote transformations in solar power generation, storage, and utilization technologies.[35]

One reason that CSP and other renewable energy sources have trouble competing with fossil fuels is the fact that the environmental benefits of not releasing harmful pollution are undervalued.[36] This is a result of fossil fuel burning plants not internalizing the environmental costs of their activities.[37] An often-proposed solution to this problem is to implement a carbon tax requiring power companies to pay for the carbon dioxide they release into the atmosphere.[38] This would force them to incorporate some of the environmental costs of burning fossil fuels into the price of the energy they produce and put them on equal footing with renewable energy producers.[39] Although most carbon tax proposals suggest softening the blow to consumers by simultaneously reducing household tax burdens, there has not been much political will to increase the price of energy in our slowly recovering economy.[40]

Despite the higher costs, many states are moving forward with plans to promote renewable energy by implementing Renewable Portfolio Standards (RPS).[41] State RPSs require utilities to generate or acquire a certain percentage of their power from renewable sources.[42]

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[34] Aaron Tucker, *Government Intervention in Clean Energy Technology during the Recession*, 42 TEX. ENVTL. L.J. 347, 355 (2012).
[35] *Id*.
[36] Silvio Marcacci, *Is Concentrating Solar Power The Technology That Saves Humanity?*, CLEANTECHNICA, http://cleantechnica.com/2013/06/14/is-concentrating-solar-power-the-technology-that-saves-humanity-read-more-at-httpcleantechnica-com20130614is-concentrating-solar-power-the-technology-that-saves-humanity/ (last viewed Jan. 7, 2014).
[37] *See id*.
[38] *See id*.
[39] *See id*.
[40] James Handley, *Could the "Green Paradox" Thwart a Carbon Tax?,* CARBON TAX CENTER (October 23, 2013), *available at* http://www.carbontax.org/blogarchives/2013/10/23/could-the-green-paradox-thwart-a-carbon-tax/.
[41] Glennon *supra* note 6, at 106.
[42] *Id*.

California has taken the most ambitious approach by requiring thirty-three percent of their power to come from renewable sources by 2020.[43] Colorado is not far behind, requiring thirty percent while Oregon and Nevada both require twenty-five percent.[44] These RPS requirements are allowing CSP plants to take advantage of Power Purchase Agreements (PPA) with utility companies that ensure all the power they produce will be sold at an agreed upon price for the foreseeable future.[45] The effect of these RPSs combined with the resulting PPAs is that much of the risk associated with developing new CSP projects can be mitigated.[46]

Competing for Resources

For obvious reasons, CSP plants are most cost effective in locations where the sun is most intense.[47] Unfortunately, this requirement corresponds best with the Southwestern United States where another necessary input, water, can be extremely scarce.[48] Along with sun and water, CSP plants also require vast amounts of land.[49] Agricultural and environmental concerns weigh heavily on resource allocation policies in this part of the country.[50] Being able to balance competing interests regarding these resources is important to CSP's success.[51]

Most CSP systems, like traditional power plants, use water for two main purposes, the steam cycle and the cooling cycle.[52] Because the water in the steam cycle is continuously recycled, the amount consumed is quite low.[53] However, substantial quantities of water are

[43] *Id*. at 107.
[44] *Id*.
[45] *Id*. at 109.
[46] *Id*.
[47] Staudenmaier, *supra* note 4.
[48] *Id*.
[49] *See* Glennon *supra* note 6, at 94.
[50] *Id*. at 134.
[51] *Id*.
[52] *Id*. at 97–98.
[53] *Id*. at 98.

needed in the cooling cycle to condense the steam back into water.[54] In an open loop cooling system, the water is diverted from a natural source and then returned to the environment after being used.[55] Although very little water is consumed in an open loop system, it is returned to the source at a much higher temperature, which can wreak havoc on natural ecosystems.[56] In a closed loop cooling system, which is the most prevalent, a large portion of the water must be evaporated in order to cool it back down for reuse.[57] Water consumption in closed loop CSP systems is roughly twice as high as that used by coal or biomass power plants.[58] It is also possible to use dry cooling or hybrid systems but they are less efficient and substantially increase the cost of an already expensive form of power generation.[59]

Water use concerns regarding power generation are nothing new.[60] In 1975, the California State Water Resources Control Board adopted the policy that, due to the possibility of widespread future water shortages, it would approve the use of freshwater resources for power plant cooling "only when it is demonstrated that the use of other water supply sources or other methods of cooling would be environmentally undesirable or economically unsound."[61] This is a serious concern for California, the biggest agriculture producing state in the country.[62]

Lately, water consumption by CSP facilities has become an issue increasingly scrutinized by state utility regulators, public land managers, environmental organizations, and Congress.[63] Regulators in California and Arizona have considered imposing water restrictions on future CSP

[54] *Id.*
[55] *Id.*
[56] *Id.* at 101.
[57] *Id.* at 98.
[58] *Id.* at Table 1.
[59] *Id.* at 99.
[60] Staudenmaier *supra* note 4, at 41.
[61] *Id.*
[62] *See generally* Glennon*supra* note 6.
[63] Staudenmaier *supra* note 4, at 40.

plants,[64] and the Environmental Protection Agency (EPA) has raised concerns to the Bureau of Land Management (BLM) about water usage at a proposed CSP plant outside of Phoenix, Arizona.[65] In 2010, Senator Jon Kyl (R-AZ) released an influential report exploring one of the dilemmas facing the CSP industry: the areas most suitable for production of solar power are the areas where water is the scarcest.[66] One of the solutions to the water problem brought up in Senator Kyl's report is to use "degraded water … such as city wastewater" in the CSP cooling cycle.[67] This solution, already employed by a nuclear plant outside of Phoenix, makes sense because the amount of wastewater produced increases with the growth of population and demand for electricity.[68] One thing is for sure; future CSP viability is greatly dependent on our ability to balance the water needs of ecosystems, agriculture, human consumption, and power generation.[69]

Land use for solar plants is also a contentious issue.[70] According to Sandia National Laboratories' estimates, CSP plants require approximately ten times as much land as traditional power plants to produce the same amount of electricity.[71] However, the amount of land needed is roughly equal when factoring in the mining and production requirements for fossil fuels.[72] This is still slightly less than the amount of land required for PV power generation.[73] While open land is abundant in the Southwest, using it for CSP power generation poses a number of problems

[64] *Id*.
[65] *Id*.
[66] *Id*.
[67] *Id*.
[68] *Id*.
[69] *See generally id*.
[70] *Id*.
[71] Glennon *supra* note 6, at 103.
[72] Marcacci, *supra* note 36.
[73] *NREL Report Firms up Land-Use Requirements of Solar*, NATIONAL RENEWABLE ENERGY LABORATORY (July 30, 2013), *available at* http://www.nrel.gov/news/press/2013/2269.html.

such as high costs and complex permitting processes resulting from competing environmental concerns.[74]

The BLM is the organization the responsible for stewarding much of our public land.[75] They have, in effect, disincentivized solar energy by charging extremely high rental rates to CSP plants using federal land.[76] The fees are comprised of a base rate, determined by the perceived agricultural value of the land that varies by location, and a megawatt fee, based on the type of project being built.[77] The more efficient and reliable a system installed on the land is, the higher the megawatt fee.[78] To put it bluntly, BLM generates large amounts of revenue by allowing private developers to use federal land to produce clean energy and punishes them for doing it efficiently, in turn driving up the cost.[79] This land would generate little or no revenues for BLM in the first place.[80]

Another major impediment to CSP development on public land comes from the same environmental groups that, in theory, support utility-scale solar projects.[81] Although these groups are some of solar power's most ardent supporters, contentions arise whenever a specific site is proposed.[82] Speaking at Yale in 2008, Governor Arnold Schwarzenegger said something that actually made sense: "They say that we want renewable energy, but we don't want you to put it anywhere. I mean, if we cannot put solar power plants in the Mojave Desert, I don't know where

[74] Glennon *supra* note 6, at 113.
[75] *Id*. at 109.
[76] *Id*.
[77] *Id*.
[78] *Id*.
[79] *Id*.
[80] *Id*.
[81] *Id*. at 116.
[82] *Id*.

the hell we can put them."[83] The Ivanpah plant, thought to be perfectly situated between a natural gas plant, a casino, and a strip mall on land used for off-road vehicle recreation, is a good example of this conflict.[84] While the site reportedly has no endangered species, seventeen threatened desert tortoises where found to be living there, which categorizes the land as a "least important" habitat for the species.[85] In order to satisfy the various environmental groups' demands, site developers had to reduce the plant's footprint by twelve-percent and spend $20 million on a relocation, protection, and monitoring program for the tortoises.[86]

The Environmental Impact Studies required before a CSP plant can be approved on public land can cost millions of dollars and take up to twelve years to complete.[87] The BLM, in order to allay environmental as well as business concerns, has made some important changes to the process.[88] They have removed environmentally sensitive land from consideration, identified areas where it makes most sense to build solar plants, and created a Programmatic Environmental Impact Statement that will act as a model for future developers to work from and possibly make the permitting process more efficient.[89]

One innovative solution to mitigate the environmental impact of large renewable energy projects is to site them on previously contaminated lands such as landfills, brownfields, and mining areas.[90] In 2008, the EPA launched the "RE-Powering America's Land Initiative" mapping and screening tool, which provides screening results for renewable energy potential at

[83] *Id*. at 120.
[84] *Id*. at 117.
[85] *Id*.
[86] *Id*. at 118.
[87] *Id*. at 113.
[88] *Id*.
[89] *Id*.
[90] *EPA, NREL Screen Contaminated Sites for Renewable Energy Potential*, DEPT. OF ENERGY SUNSHOT INITIATIVE (August 28, 2013), *available at* http://www1.eere.energy.gov/solar/sunshot/news_detail.html?news_id=19566.

66,000 contaminated sites across the country.[91] Working with the Department of Energy's National Renewable Energy Laboratory (NREL), they developed screening criteria for solar power potential at various levels of development.[92] By transforming America's liabilities into assets, this plan is a win-win for society.[93] In 2013, this initiative was recognized as one of the "Top 25 Innovations in American Government" by Harvard University.[94]

Another plan that has been gaining traction is to site CSP plants on private, ecologically disturbed land previously used for farming.[95] The Solana plant, for instance, uses more than three square miles of land that had previously been used to grow alfalfa.[96] It consumes seventy-five-percent less water than was needed for agricultural uses and produces a much higher-value product.[97] The reallocation of land and water from low-value farms to CSP plants offers an environmentally sound and economically viable alternative to siting projects on federal lands.[98]

Conclusion

Concentrating Solar Power is but one promising component of the complex renewable energy portfolio needed to end our country's reliance on fossil fuels and slow the pace of climate change.[99] Somewhat ironically, this solution to help prevent the degradation of our environment has the potential to create serious environmental consequences of its own. Water usage and

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[91] *Id*.
[92] *Id*.
[93] *EPA Screens More Than 66,000 Contaminated Sites for Renewable Energy Potential*, ENVTL. PROT. AGENCY (AUGUST 5, 2013), *available at* http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/1453114a4728fa0385257bbe00580004!OpenDocument.
[94] *Id*.
[95] Glennon, *supra* note 6, at 127.
[96] *Id*.
[97] *Id*. at 128.
[98] *Id*. at 128.
[99] *See* Pool, *supra* note 3, at 24.

ecosystem damage are the two biggest environmental concerns associated with CSP.[100] While CSP plants do have some direct negative impacts on their immediate environment, failing to implement these technologies will have a much greater overall impact on the environment caused by increased greenhouse gas emissions.[101] Cooperative initiatives between governmental agencies, environmental groups, and private enterprises have come up with innovative solutions to solve some of these problems.[102] Along with making CSP more environmentally friendly, a major goal of these initiatives is to make CSP and other renewables economically competitive with traditional forms of power generation.[103] The future of concentrating solar power depends on our willingness as a country to prioritize our sustainability goals and take the steps necessary to accomplish them.[104] We are making important strides in that direction by creating a policy framework for balancing our competing needs in an increasingly scarce environment.[105]

[100] *See* Glennon, *supra* note 6, at 103.
[101] *Id*.
[102] *See SunShot Initiative: About the Solar Office*, DEPT. OF ENERGY, http://www1.eere.energy.gov/solar/sunshot/about.html (last viewed Jan. 7, 2014).
[103] *See SunShot Initiative: Concentrating Solar Power*, U.S. DEPT. OF ENERGY, http://www1.eere.energy.gov/solar/sunshot/csp.html (last viewed Jan. 7, 2014).
[104] *See generally* Glennon, *supra* note 6.
[105] *See* Pool, *supra* note 3, at 14.