Solar power – the hidden threat to water supplies

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Concentrating solar power plants seem in many ways like a silver bullet for the world's energy problems - but have we looked closely enough at their environmental impacts?

In response to the threats posed by climate change, recent years have witnessed a rapid increase in the levels of energy harnessed from renewable sources, particularly wind and solar. However, despite offering a great deal of potential as a major future source of zero-carbon energy, concerns are growing that one particular type of solar power, known as concentrated solar power, may pose a significant threat to water supplies in some of the world's driest regions.

What is Concentrated Solar Power?

For many of us, solar power means solar panels. Also known as photovoltaic (PV) panels, these are an increasingly common sight on urban rooftops and industrial-scale facilities worldwide. However, photovoltaic panels are not the only way that the sun's energy can be captured. In particular, Concentrated Solar Power (or CSP for short), is emerging as a viable alternative to PV. CSP produces heat or electricity using hundreds of mirrors to concentrate the sun's rays to a very high temperature.

The CSP industry is rapidly gaining mainstream acceptance, with the number of projects under consideration starting to multiply. In its recent report, ‘Concentrating Solar Power Global Outlook 09 - Why Renewable Energy is Hot’, Greenpeace International predicted that 'with advanced industry development and high levels of energy efficiency, CSP could meet up to 7 per cent of the world’s power needs by 2030 and fully one quarter by 2050,' adding that 'CSP has taken off, is about to step out of the shadow of other renewable technologies and can establish itself as the third biggest player in the sustainable power generation industry'.

CSP and Water Use

All solar technologies use water for cleaning solar collection and reflection surfaces such as mirrors, heliostats, panels, and troughs. According to a recent U.S. Congressional Research Service report, ‘Water Issues of Concentrating Solar Power (CSP) Electricity in the U.S. Southwest’, solar technologies use approximately 20 gallons of water per megawatt hour for cleaning purposes. Crucially though, CSP technologies also need to be cooled at the so-called 'cold' end of the steam turbine cycle. This can be achieved through evaporative (wet) cooling, where water is available, or through dry cooling (with air) - both conventional technologies.

The amount of water used in these systems varies greatly depending on the technology and cooling system used. However, because it is usually cheaper, and therefore much more widely used, CSP plants typically use water as a cooling mechanism. According to the Congressional Research Service report, this ‘wet-cooling’ technology has the potential to use significantly higher levels of water than all other generation sources, including nuclear and ‘traditional’ coal or oil-powered plants.

With potentially hundreds of square miles of the earth’s surface due to be set aside for CSP generation in the future, now is a good time to ask whether this largely ‘environmentally friendly’ technology may also have negative effects on local ecosystems. In particular, the true environmental cost of CSP plants, particularly in terms of their effect on local water eco-systems, as well as groundwater and aquifer supplies, is a subject that merits much closer consideration.

Dry Cooling

A recent U.S. Department of Energy report, ‘Reducing Water Consumption of Concentrating Solar Power Electricity Generation’, has shown that CSP plants that use so called ‘dry-cooling’ systems have a significantly smaller water-use footprint than traditional power plants. In the US, BrightSource Energy has committed to dry-cooling at its plants, which could potentially reduce water-usage by more than 90 per cent. At its Ivanpah Solar Energy Generation Station (SEGS) it plans to employ dry-cooling, closed-loop recycling and conservation to keep water-usage under 100 acre feet annually.

'For comparison, a recently proposed 250 megawatt parabolic trough solar plant in California using wet cooling would consume 1,600 acre feet of water annually,' says Keely Wachs, Senior Director of Corporate Communications at BrightSource. 'This is nearly 25 times the amount of water per megawatt hour that will be consumed at the Ivanpah SEGS.

'Dry-cooled tower power-plants use 25 times less water than wet-cooled parabolic-trough plants. When using dry-cooling technology, a power tower plant will also have a much less significant efficiency hit than a parabolic trough plant due to its ability to reach higher steam temperatures,' he adds.

The only water used at the site, for washing the mirrors, will be drawn from local aquifers. BrightSource says that groundwater analyses indicate that Ivanpah’s water-use won't measurably impact local groundwater underflow, leading California Energy Commission staff to determine that the site’s water-use impact ‘would not be significant.’


'Tower'-style CSP systems may have a water-use advantage over 'trough'-style alternatives

Dry Vs Wet – A question of cost?

Based on this analysis, you might be forgiven for assuming that the correct course of action would be to ensure that all future CSP plants use dry-cooling. However, as is often the case, the picture is blurred by broader financial considerations. To begin with, although dry-cooling uses less water, initial capital costs are higher, meaning that wet-cooling is often more cost-efficient in water-rich areas. Some estimates suggest that dry-cooling eventually leads to 5 – 10 per cent higher costs compared to wet-cooling.

The current industry metric for assessing the cost penalty of dry-cooling is the above mentioned U.S. Department of Energy Report, which summarizes industry knowledge. According to Hualapai Solar, it confirms that evaporative-cooling is more cost-efficient than dry-cooling in water-rich areas.

'In general, you can assume that a dry-cooled solar power plant will create electricity... for 10 per cent more than it costs to create electricity using wet-cooling,' says Greg Bartlett, Project Director at the Hualapai Valley Solar Project.

So what about water-stressed areas? Most dry-cooled plants remain at the proposal stage, but as they emerge we are likely to get better information with which to judge their efficacy. In any region, it will always be best to minimise the amount of groundwater used to cool a power-plant, and for some, hybrid-systems show the most promise.

'That said, it will take time for these hybrid-systems to transition from the start-up and academic phase and into the bank-financed and operating phase,' says Bartlett.

Regulatory Pressure

Even though wet-cooling is more cost-efficient, water-usage remains unacceptably high for many regulators. In California, developers planning utility-scale plants are not likely to be permitted to construct using a wet-cooled option. Some companies have already faced environmental hurdles because protests against high-levels of water-usage at CSP-plants in the state. However, in other states that are more 'flexible', the chances for wet-cooled power-plants significantly increase.

'Nevertheless, water is a scarce resource and developers should be engineering options with and without water to ensure that project-economics work and that [planning consent] can be achieved for dry-cooled options which produce less energy on a yearly basis,' says Albert Fong, Chief Project Engineer at Albiasa Corporation.

In the US at least, it may be that in future each state will create its own policies, which it might be reasonable to expect would be site-specific.

'In other words,' says Bartlett, 'there are plants planned in California, for example, above aquifers that simply have no water in them, certainly not sufficient water to cool the proposed power-plant. For these projects, dry-cooling is the only option.'

Making Use of 'Waste' Water

As we have seen, when choosing plant-cooling options, CSP-developers are often faced with stark choices between cost-efficiency and water-usage, with costs differing from site-to-site depending on ease of access to local water supplies. As the CSP industry expands, regulatory pressure and mounting water-scarcity will drive many developers to explore alternatives to wet-cooling, perhaps leading to increased efforts to improve the cost-efficiency of hybrid and dry-cooling options.

In the arid Southwestern US, the Hualapai Valley Solar project uses an evaporative-cooling system that reuses cooling-water more than 50 times. The primary source is wastewater from a municipal plant, supplemented by local groundwater. Evaporative-cooling, they say, is currently the only competitive system due to cost penalties associated with dry-cooling and hybrid-cooling systems.

'Groundwater use was the public's greatest concern, which was mitigated by the use of treated wastewater as our primary source of cooling-water,' says Bartlett.

Looking ahead

Although economic concerns are obviously important when making any investment decisions, the unique location of many current and planned CSP plants in some of the world's most arid regions means that developers should also place equal importance on minimising the water-footprint of facilities. After all, deserts are deserts precisely because they have very little water.

Paradoxically, one of the main projected future uses of CSP is for desalination, or turning sea water into water for drinking or irrigation for populations in arid areas. Further research and investment into this application of CSP technology could also help to offset any detrimental effects on global and local water supplies.

It is possible that many developers may be tempted to think that they will be under less pressure to consider water-use due to the sheer remoteness many sites, but people who live there are likely to see it very differently. In this light, developers would be well-advised to act now in an effort to avoid anti-CSP sentiment based on environmental grounds, as has already happened with wind energy in the UK. In doing so, they will need to involve local communities in making location decisions and in distributing potential rewards.

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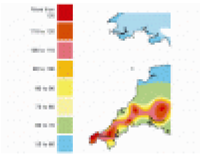

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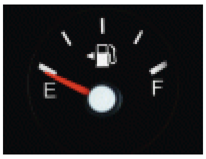

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