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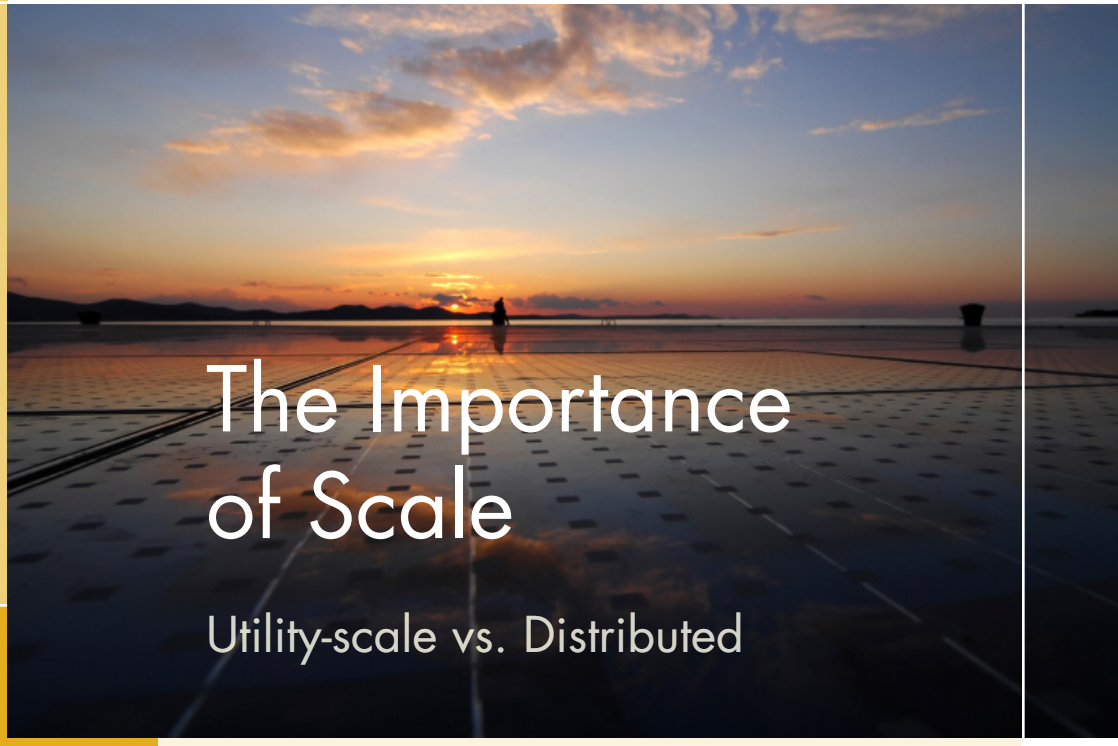
Arizona's Solar Energy Future

Fact Sheet 4 in a series



The Importance of Scale

Utility-scale vs. Distributed

Solar panels on every roof, or a handful of utility-size power plants on empty land: How will Arizona answer the challenge to capture the tremendous solar resources at its disposal? The question of what approach to take has sparked questions and debate. The answer, most likely, is through all of the above and in between.

A CHARGE TO CAPTURE THE SUN

Seeking to capitalize on its solar resources and diversify the state's energy sources, Arizona in 2006 adopted a policy called the Renewable Energy Standard (RES). This policy requires that 15 percent of the retail electricity sold by the states' regulated utilities be generated by renewable sources by 2025. The policy further requires that a growing percentage of this renewable energy be generated by "distributed" sources, smaller power generators located on-site or close to the end user, rather than by centralized power plants feeding power into the electric transmission grid. By 2011, 30 percent of the state's renewable energy mix must come from distributed generation.

Arizona's distributed generation requirement will certainly encourage the installation of residential rooftop solar energy systems. But how far can rooftop solar energy systems realistically take us in terms of satisfying the RES and effectively displacing carbon emissions from fossil fuel-based electric generation?

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What's the Goal?

According to estimates by the Arizona Corporation Commission, the regulatory body governing utilities, it will take 7,478 gigawatt hours (GWh) of renewable generation by 2025 to satisfy the RES. Of this, 2,243 GWh will be required to come from distributed sources, with 5,235 GWh coming from non-distributed sources.[1] To put this in perspective, Arizona generated a total of about 865 GWh of solar electricity in 2007.[2] What's the best way to quickly and efficiently develop over 6,600 GWh (6.6 million kilowatt hours) of solar power in the next 15 years?

What are the Tools?

Proven solar power technologies today consist of photovoltaic (PV) and concentrated solar thermal (CST). PV systems consist of solar panels containing semiconductor materials that generate electricity by absorbing sunlight and releasing electrons. Perhaps most familiar as rooftop systems, PV technology is very flexible in terms of sizing. With the addition of more panels (and land), they can range from residential systems of a couple of kilowatts (kW) to utility-scale power plants of hundreds of megawatts (MW).

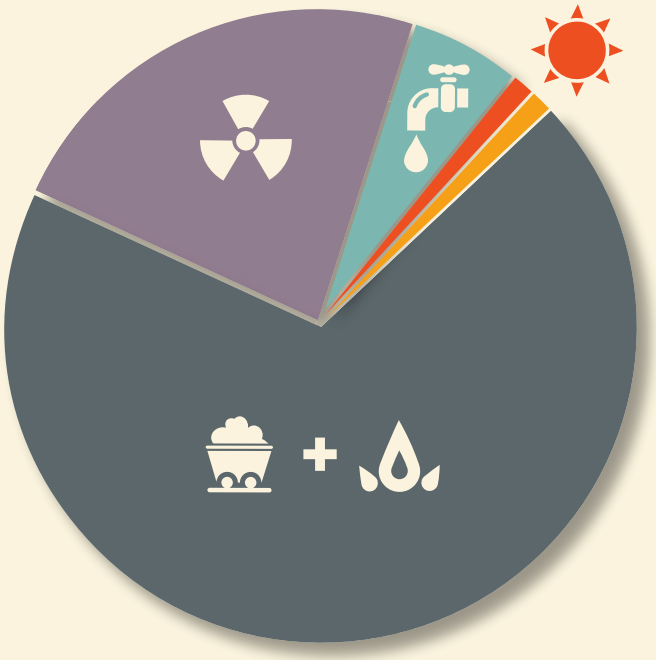
In between, at the "community-scale" size, they can serve the needs of a group of end users located close by. One key feature PV systems lack is the ability to cost-effectively store energy for later use. PV electricity must be used when it is generated, regardless of the needs of consumers or the power grid. This inability to store power also means that PV plants are subject to intermittent outages from passing clouds.

CST systems use a steam turbine similar to those found in most conventional generating plants. With CST, instead of burning a fuel or splitting an atom to generate the heat that creates steam to turn the turbine and generate electricity, CST plants use fields of mirrors tracking the sun to concentrate the sun's heat to eventually create the steam. CST plants are large, between 50 and more than 500 MW, and require significant amounts of water for cooling and vast tracts of land.

Recognizing that the ultimate electric generation portfolio for meeting Arizona's RES will necessarily consist of a variety of sizes and types of renewable energy systems, we will examine two extreme cases of solar generation in order to illustrate the challenge of generating so many gigawatt hours from small,

Arizona's Energy Generation Mix Today*[3]

- 70% Coal and Natural Gas
- 24% Nuclear
- 6% Hydro
- Less than 1% Non-Hydro Renewables
- Less than 1% Other



*Based on Projected Energy Mix for 2009.



distributed sources. In one case, all of the RES is met by residential-scale photovoltaic (PV) systems; in the other, all of the RES is met by utility-scale concentrated solar thermal (CST).

In order to meet the 2025 Arizona RES, there will need to be 7,478,864,025 kWh (7,478 GWh) of renewable energy generated in Arizona. The table below shows us that in order to accomplish that target, we would need over 2 million residential PV systems. Since there were approximately 2.1 million housing units in Arizona reported in the 2000 census,[4] nearly every home in the state would have to have a 2 kW PV system to satisfy the RES requirements this way. In contrast, the same amount of energy could be supplied with only 11 CST plants. In addition, note that the cost of those 2 million PV systems would be roughly twice the cost of the comparable CST systems.

Community Scale: A Middle Ground

Based on size and cost, it appears both easier and more cost-effective to build a few larger plants than many small ones. But size and cost are only two of a myriad of factors to be considered, such as the water requirements of the CST systems. A middle-ground option that is beginning to gain some traction in the U.S. is the so-called "community-scale" system. Larger than typical residential and

FACTS ABOUT POWER

1 kilowatt = 1,000 watts

1 megawatt= 1,000 kilowatts

1 gigawatt= 1,000 megawatts and 1 million kilowatts

The smallest utility-scale plants, at 100 MW, are 50,000 times larger than a typical 2 kW residential system.

Comparison of Social Cost to meet AZ RES with Residential PV vs. Utility-scale CST Systems

	Units	Residential PV	CST
Average Size	kW	4	250,000
Cost/Watt	$/W	5.00	5.00
Cost/System	k$	20	1,250,000
Average Capacity Factor*	%	20	30
Average Annual Generation	MWh	7	657,000
Number of Systems Required	—	1,067,190	11
Total Cost	B$	21.3	18.5

*Capacity factor: the ratio of the actual output of a power plant over a period of time and its output if it had operated at full capacity the entire time.

Source: The Sonoran Institute.





commercial rooftop systems but smaller than utility-scale plants, these distributed systems, typically PV, are located close to and serve a single entity or end user. The U.S. military has demonstrated the feasibility of community-scale systems, using on-site solar energy systems to supplement conventional power supplies at Nellis Air Force Base in Nevada and Twentynine Palms Marine Corps Base in California's Morongo Basin. Completed in 2007, the Nellis AFB 14 MW PV system supplies more than 25 percent of the power used by the base population, roughly 12,000 people.[5] The Marine base at Twentynine Palms has been using a 1.29 MW PV system since 2003 to supply about 5 percent of the base's energy requirements.[6]

Conclusion

Clearly, it is not realistic nor expected that every homeowner in the state will purchase and install a rooftop PV system within the next 15 years and enable Arizona to satisfy its RES requirements solely in this manner. Utility-scale CST plants, based on their ability to reliably produce large amounts of energy at a lower cost, will necessarily play a significant role in the state's solar energy future. That said, today's CST plants face challenges of their own, such as their need for significant amounts of water to operate most economically and efficiently. And while the outlook is good for CST to overcome its technical challenges, Arizona's RES requirement that 30 percent of the states' renewable energy mix must ultimately come from distributed generation means that utility-scale solar plants will not provide the whole solution either.

Community-scale distributed systems may emerge to help fill the gap. The one thing that does appear certain is that Arizona's renewable energy mandate will require—and inspire—a mix of technologies and a range of solar energy system size options to achieve its renewable energy goals.

Select photos courtesy of National Renewable Energy Laboratory (NREL)

The Sonoran Institute inspires and enables community decisions and public policies that respect the land and people of Western North America.

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Footnotes

1 Arizona Corporation Commission Decision # 69127, Docket # RE-00000-05-0030, *In the Matter of the Proposed Rulemaking for the Renewable Energy Standard & Tariff Rules* (2006). Retrieved from: http://www.azcc.gov/divisions/utilities/electric/res.pdf

2 Department of Energy, Energy Information Administration Table 1.18 *Renewable Electric Power Sector Net Generation by Energy Source and State*, 2007. Retrieved from: http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/table1_15.pdf

3 Department of Energy, Energy Information Administration, Form EIA 906, *Power Plant Report* and EIA 920, *Combined Heat and Power Plant Report*.

4 U.S. Census Bureau, American FactFinder, DP-4. *Profile of Selected Housing Characteristics*: 2000. Retrieved from: http://factfinder.census.gov/servlet/QTTable?_bm=n&_lang=en&qr_name=DEC_2000_SF3_U_DP4&ds_name=DEC_2000_SF3_U&geo_id=04000US04

5 U.S. Air Force, *Nellis Air Force Base website. Nellis Activates Nation's Largest PV Array* (December 18, 2007). Retrieved from: http://www.nellis.af.mil/news/story.asp?id=123079933

6 BP Solar, *USMC 29 Palms, 29 Palms California*. Retrieved from: http://www.bp.com/liveassets/bp_internet/solar/bp_solar_usa/STAGING/local_assets/downloads_pdfs/29PalmsTag.pdf

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