KW (H20) – USING SUNSHINE TO POWER ARIZONA'S WATER FUTURE A SURVEY OF ARIZONA WATER OPERATORS WITH SOLAR

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The Environmental Protection Agency (EPA) estimates drinking water and wastewater systems account for 3 to 4 % of energy use in the United States and 3% of the nation's energy consumption costing nearly $4B annually (U.S. EPA, 2012b). The Energy Management & Sustainability (EM&S) Committee of the AZ Water Association formed in 2014 to educate and collaborate with professionals in the water industry on the water-energy nexus and sustainability best practices. Recently the EM&S Committee conducted a survey of city officials, water operators and energy managers in Arizona with solar installations at water and wastewater plants. The survey sought to identify how much solar energy exists at Arizona water facilities; key decision factors driving solar implementation; and their experiences, including any valuable "lessons learned."

Solar Beginnings and Declining Costs

On April 25, 1954, scientists at Bell Labs in New Jersey announced the invention of the first practical silicon solar cell (APS Physics, April 2009). They demonstrated their solar panel by powering a small toy Ferris wheel with a solar powered radio transmitter. The New York Times commented "the silicon solar cell may mark the beginning of a new era, leading eventually to ….the harnessing of the almost limitless energy of the sun." A year later Western Electric licensed commercial solar cell technologies and Hoffman Electronics created a 2% efficient commercial solar cell priced at $1,785/watt.

Today solar costs approach $2.00 /watt nationally (Solar Energy Industry Association (SEIA), 2016) – Figure 1. In the last five years solar costs declined by 64% in Arizona and utility scale solar now averages between $0.03 and $0.05/kWh. (SEIA, December 2016). Two of the cities surveyed with 2017 installations over 1 MW reported fixed solar power costs of under $.06/kWh and $.055/kWh – highlighting solar costs continue to decline even without utility incentives.

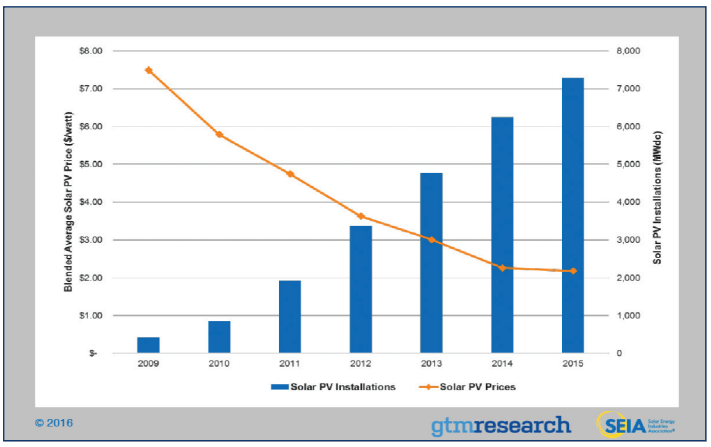


Figure 1. Solar Cost and Installations

Solar in Arizona

Arizona ranks 3rd nationally in solar deployment with 2,965 megawatts (MW) of installed capacity. Solar at Arizona water plants accounts for about 6% of commercial solar installations statewide. Figure 2 profiles Arizona water plant solar sizes, production and operational dates from Peoria's 59.6 kW turn up in 2010 to Scottsdale's 2.3MW installation with Tesla batteries later this year. Solar capacity at Arizona water plants totals 24.5MW and is expected to generate nearly 50M kWh annually. This amount of clean energy production is equivalent to reducing CO2 emissions from 18,748 tons of coal; or 3,953,900 gallons of gas; or 81,354 barrels of oil.

Arizona Water Plants with Solar Systems Community	Project Completion *Anticipated*	Size kW-DC	2016 kWh Production *(Estimated via PV Watts)*	Lease/Purchase
Bisbee	8/1/13	400.0	*700,000*	Purchase
Douglas	2/1/16	297.6	494,098	Purchase
Flagstaff[1]	12/19/13	818.4	1,371,365	SSA
Gila Bend	12/1/12	460.0	*832,000*	Purchase
Gilbert	11/1/11	2,257.9	4,426,361	SSA
Globe	12/21/12	495.5	*895,000*	PPA
Kingman	12/20/12	50.0	*92,000*	Purchase
Peoria - Beardsley Water Plant	1/1/10	59.9	107,585	Purchase
Phoenix	1/1/13	7,500.0	15,200,000	PPA
Pima County	2010, 2011	2,000.0	3,450,000	PPA
Prescott Valley	4/1/12	1,460.0	2,263,645	PPA
Scottsdale - (under design)	*8/1/17*	2,300.0	4,783,839	SSA
Somerton	2013	272.0	274,000	Purchase
Tempe - South Water Treatment	3/1/14	924.0	1,600,000	SSA
Tempe - Johnny Martinez	*3/20/17*	1,200.0	1,820,000	SSA
Tucson - Central Avra Valley Storage and Recovery Program (CAVSARP)	3/2011 & 12/2013	4,000.0	11,010,000	PPA
Totals		**24,495.3**	**49,319,893**	

1 Flagstaff 2015 production data

Figure 2. Profile of Communities in Arizona with Solar at Water Plants

Communities with Owned Solar

Six Arizona communities purchased solar systems. A key factor in decisions to own their solar were low interest loans from the Water Infrastructure Finance Authority (WIFA). WIFA offers a "green project" program using EPA grant monies for sustainable construction like water and energy efficiency, green storm water and other environmentally innovative projects. An attractive financial incentive for green projects can involve debt forgiveness – sometimes over 50% for economically disadvantaged communities. The following communities secured WIFA loans for their solar construction:

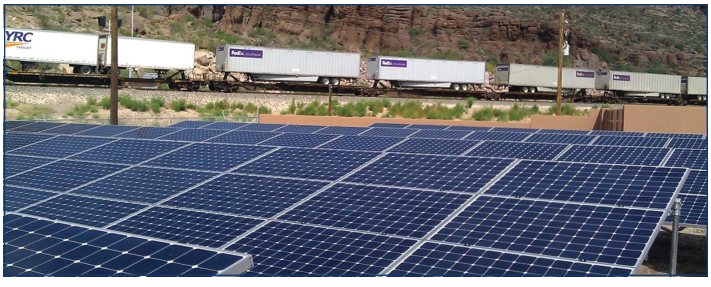
Solar at Beardsley Water Reclamation Facility Operations Building
City of Peoria

Peoria's Beardsley Road Water Reclamation Facility (4MGD) – Peoria secured a loan for overall plant upgrades involving clarifiers and UV disinfection and constructed a 59.6 kW system, producing

about 20% of plant energy in 2016. Savings and Incentives totaled $14,000 last year and are expected to be over $300,000 for the life of the solar system.

Somerton's Water and Wastewater Treatment Plants received $3.2M in WIFA loans and $1M in debt forgiveness to construct a 272 kW concentrated photovoltaic (CPV) tracking system. CPV trackers produce greater generation than ground mount systems requiring less land. However, they're more complex needing proprietary software and equipment to maintain alignment to the sun. Somerton's solar vendor went bankrupt and systems soon lost alignment, drastically lowering solar generation. City Manager Bill Lee considers Somerton "…lucky in finding someone with expertise to reverse engineer the system. We're now producing about 60% of what was promised." Mr. Lee praised the electrical contractors who installed the system, saying, "They stood by Somerton throughout and even bought surplus equipment stock from the vendor at auction." A major storm in 2015 flooded the plant damaging inverters, transformers and arrays. Somerton salvaged equipment and used surplus stock to restore the system. They plan a future repair with an adjunct tracking system to enable production to get back on track. Despite difficulties, Somerton still benefits from solar savings as their credit per kWh for on-site generation ranges from $.08 to $.12/kWh.

Gila Bend used $1.5M of their loan for a 460 kW solar system installed in March 2013 and received significant debt forgiveness. The fixed-tilt system located at the town's **Reverse Osmosis Water Treatment Plant** provides nearly 86% of the energy needs for the plant. According to Stacey Young, Finance Director, "Initially Gila Bend was not seeing much savings. The solar plant was overbuilt in regards to the amount of power the arrays were producing versus the amount of power on each utility interconnection, which determines customer credit for solar. We were fortunate Arizona Public Service (APS) greatly assisted us with adding interconnections for two wells consuming large amounts of power." Last year's solar savings were $97,000 including utility incentives.



Kingman received a WIFA loan in 2012 for construction of their **Downtown Wastewater Treatment Plant** (.5MGD) including a 50 kW-DC solar system. Engineer Phil Alred indicates, "Solar has been a good addition to the plant," meeting 20% of the plant's energy needs and is virtually "plug and play" to maintain. While Kingman had no comparative savings with the new plant, he said WIFA's debt forgiveness helped "solar show a good ROI."

Bisbee's San Jose Wastewater Treatment Plant (2MGD) – Bisbee officials decided on a 400kW solar system to offset costs at their plant. WIFA granted a loan of $1.6M with debt forgiveness of $0.4M. Bisbee water operators received certification training from a solar vendor on maintenance for inverters, panels and the electrical interconnection. Post installation, plant managers conducted an energy audit with help from APS and Tucson Water. Energy efficiency improvements in UV disinfection and pump operations reduced energy use by 30%. Public Works Director Andy Haratyk said, "Putting in solar was one of the best things we ever did" as maintenance of the system is easy and "energy savings - solar and efficiency savings less the annual WIFA loan payments - are $12,000 annually."

Douglas' WWTP (2MGD) received a WIFA loan of $1.3M with debt forgiveness of $0.4M. The project also included a new 3000 amp Service Entrance Section (SES) to upgrade reliability and provide adequate service. Luis Pedrosa, City Finance Director and Treasurer indicated savings of $25,000 were seen in 2016 with a system lifetime savings between $400,000 and $500,000. Douglas water operators manage the solar system.

Communities with Leased Solar PPA's/SSA's

According to survey respondents with leased solar, initial motivations included incentives from power utilities, no "upfront cost" Power Purchase Agreements (PPA's) or Solar Services Agreements (SSA's) and energy cost savings. With PPA's and SSA's the solar vendor offers a contracted solar power $/kWh rate over a 20-25 year term, a guaranteed annual production, and ongoing maintenance. Solar financers take advantage of the solar tax credit of 30% of project value authorized by the Energy Policy Act of 2005. The solar tax credit was extended in 2016, declining gradually to 10% in 2022 for commercial solar. The following communities with leased solar are Town of Gilbert, City of Tucson, Pima County, City of Flagstaff, Town of Prescott Valley, City of Phoenix, City of Tempe, and City of Scottsdale.

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Gilbert's Neely Wastewater Treatment Plant (11MGD) solar at 2.2 MW mounted panels in the facility's' recharge basin and adjusted panel height accordingly. Gilbert received a rate of $.075/kWh with a 2.5% annual escalator and utility incentives. Gilbert's Wastewater Manager Mark Horn indicates savings close to $2M were initially projected. He expects most savings to occur in the last 10 years of their contract but that "will depend on future utility rate increases."

Tucson's Central Avra Valley Storage and Recovery Program (CAVSARP) – (63MGD), a recharge and pumping facility, expanded their initial solar project to a 4 MW system in 2013. It produces 25% of CAVSARP's electrical use. Two PPA's were involved with differing costs for solar power and incentives from the local power company. Pumping loads have seen recent reduction with excess solar generation sold back to the utility at lower, wholesale rates. Tom Arnold, Lead Management Analyst indicates a "break-even" average cost of solar, comparable to existing utility rates. He mentioned saving money was not the sole reason for Tucson's decision to invest in solar. Rather providing "green energy with little or no increase in overall power cost" and reducing the City's carbon footprint" as other factors.

Pima County's Tres Rios WRF (50MGD) and Aqua Nueva WRF (32MGD) both site a 1MW solar system. Eric Nelson, Technical Program Manager for the Pima County Regional Wastewater Reclamation Department (PCRWRD) said, "As peak 15 minute demand is not reduced by solar, extensive analysis indicated PCRWRD could save approximately $270k per year on a better fit of plant loads with solar diurnal load profiles and a time of use (TOU) rate plan. He added, "If a viable cost effective storage option were available for solar, it might be a 'game changer'" for reducing demand charges during peak periods.

In 2017, PCRWD plans completion of the Corona de Tucson WRF solar project. Once completed, solar power will account for about 9% of total electrical power purchased by PCRWRD. The department also beneficially reuses biogas produced in its anaerobic digesters. PCRWRD expects to meet the County's renewable energy goal of 15%, ahead of its 2025 goal. PCRWD estimates their savings from renewable energy projects to exceed $4.5 million over 20 years, dependent on increases in power rates.

Flagstaff installed 818 kW of solar at their **Aquaplex, Rio de Flag and Wildcat Wastewater Plants** in 2013. The cost for the system was $2.9M. The annual energy savings from solar power, plus utility incentives, less the solar cost resulted in $40,160 savings in 2015. Cash flows estimate a savings of $2.4M to Flagstaff over 25 years, dependent on future rates. Flagstaff's City Council in 2010 passed a resolution promoting City-wide energy efficiency and renewable energy at their facilities. The City goal is to meet 35% of energy consumption by 2020; and 50% by 2050 through renewable generation or purchases. A report to the Council on electrical costs cited "rising energy costs and the City's reliance on predominately groundwater based utility system" as rationales for the resolution.

Prescott Valley's Tank Farm and Booster Station's two solar systems (695 kW) provide 50% of the power demand for the facility. The Town's **Advanced Wastewater Treatment Plant (2.6MGD)** two solar systems (765 kW) provide 30% of demand. Prescott Valley's solar footprint is 1.460 MW. Projects completed in April 2012 and

the solar provider owns and operates the system on land owned by the Town. Most surveyed communities saw no snafus with solar equipment. But Utility Director Neil Wadsworth reported meters for two systems switched and interconnected to the wrong solar systems during construction. Two incidents occurred where a solar power bus bar got excessively hot and burned up, taking a month for each repair. While plant operations were not affected, solar power was not available during that period. The Town realizes overall savings from a combination of solar power, time of use electrical rates, and control and optimization through improved SCADA systems. Mr. Wadsworth suggested, "To take full advantage of solar power pricing, future process changes require consideration to try to limit increases in the kW demand of the plant equipment, or time them to match peak solar production."

The Phoenix Lake Pleasant Water Treatment Plant (LPWTP) at 7.5 MW- DC is by far the largest on-site solar generation facility of Arizona water plants surveyed. The LPWTP photovoltaic complex began operation in January 2013 and produces about 15.2 million kWh per year. Surplus power generated is pushed back into the APS system. APS provides credits for the surplus energy, which can then be used at night, or on cloudy days. The solar was designed to meet 70% of LPWTP's energy needs at a water production rate of 50 MGD; but LPWTP is currently producing only about 27 MGD. Thus a surplus of solar credits is accumulated over the year. At the end of the year, APS pays Phoenix the prevailing wholesale rate (about $0.03 per kWh) for the accumulated credits. The LPWTP solar provider charges about $0.07 per kWh, so this arrangement results in a $0.04 per kWh for the accumulated credits. Though the LPWTP solar facility will likely be financially beneficial for Phoenix in the long run, Andy Terrey, Project Coordinator for the Water Services Department, stresses "Water utilities need to thoroughly understand how solar impacts the cost of power delivered from the grid, and how that impacts their bottom-line energy costs."

Tempe's South Water Treatment Plant (50MGD) solar sized at 924 kW became operational in March 2014 and the **Johnny G Martinez Water Treatment (80MGD)** Plant at 1.2MW plans to be operational in March 2017. Solar panels are expected to provide 15% of the South WTP's and 30% of the Johnny G Martinez WTP's energy needs. Estimated savings over the 20 year SSA's are $1M and $0.530M, respectively. A comparison of Tempe solar projects over time provides insight regarding utility rates and solar costs. The South WTP project received an incentive of $.04/kWh from its utility provider with a $.05/kWh cost of solar power. Thus the solar company received $.09/kWh to construct and maintain Tempe's 1st project. Solar power costs for Tempe's 2nd project are fixed at $.055/kWh with no incentives. In three years time, solar provider cost declined dramatically but Tempe's cost rose marginally by $.005/kWh. This and changes in utility rate structures – reductions in $/kWh rates but increases in demand charges – led to more conservative savings forecasts for the 2nd project. Grace Kelly, Energy Coordinator for Tempe likes "the use of SSA's as the City gets a facility powered by renewable energy with no upfront capital costs and ease of a "turnkey" system for design, build and maintenance." The City also has solar at its Library and Police/Courts complexes. Ms. Kelly cited Tempe's City Council resolution to power 20% of municipal operations from renewable energy by 2025 as a major driver for solar in the City.

Scottsdale's Water Campus plans a 2.3 MW solar installation in 2017 to generate 4.8 MWh annually and between 10 to 15% of their water (70MGD) and wastewater (20MGD) plants electrical needs. According to Chris Hassert, Water Resources Planning & Engineering Director, "Telsa Battery Storage is an integral part of our strategy. Solar alone does not shave cost. A solar with battery combination allows cost savings in demand charges and is estimated to save $1.4M over a 20 year period." He adds, "Solar also benefits the water campus by diversifying the power supply portfolio and adds additional redundancy."

Lessons Learned

1. **Right Size the Solar System –** Douglas' Luis Pedrosa counsels it's best to maximize energy efficiency opportunities prior to solar implementation and operators should as a first step"… identify and employ operational efficiency strategies and audits to ensure the facility is being operated as designed." This would mitigate lessons learned for some communities who found their solar systems sized too large or not balanced between separately metered plant loads. Others experienced reductions in MGD or pumping loads. Phoenix's Andy Terrey warns, "Never size solar generating system larger than the facility's minimum anticipated monthly energy use." While solar vendors perform historical analysis of a facility's energy use, its incumbent on water managers to provide plant forecasts or impacts affecting long-term energy use to solar providers. Power utilities can also provide valuable guidance and support in this effort.

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2. **Understand Utility Rate Structures and Plans –** Power utilities employ either kW or kWh values to determine the appropriate rate plan for the plant. Solar reduces overall kWh load and may reduce kW demand (if peak demand occurs diurnally). This can result in a change to a lower usage utility rate plan with higher costs. Or as PCRWRD discovered, a TOU utility plan may be a better fit than a standard plan. Knowing differences between "export" rate and "offset" rate and how solar billing works is also important. Tempe's Grace Kelly, after navigating these complexities, suggests "Hiring a third-party consultant familiar with utility rates to vet solar proposals, assess utility rate impacts and determine the best financial outcome" can be key to a successful solar implementation.
3. **Have a Plan and a Back-up Plan –** Pima County, Flagstaff, Tempe, and Tucson developed plans or goals for renewable energy. As gleaned from survey responses, sustainability goals foster a longer term systemic approach to energy saving opportunities. While the survey found successful outcomes for all solar projects, detailed technical and financial planning occurred more often in communities with plans and goals. Another byproduct of systemic planning appears to be development of staff depth of knowledge and expertise to perform analyses for continued improvement. Several respondents commented on taking advantage of solar benefits - like demand reduction; integration with SCADA schedules; or rate plan analyses to maximize savings. Hopefully all communities will plan to optimize plant processes as expertise increases with solar. A back-up plan refers to weighing alternatives or options available if projects "don't always turn out according to plan." Somerton's securing expertise and procurement of surplus equipment for system repair; and Gila Bend's experience of adding on site load offer good examples of managing unanticipated project contingencies.
4. **Pay Attention to Policies –** Recent utility rate case policies on charges and net metering led to often contentious disagreements between power utilities and the solar industry. This created uncertainty for customers on future utility and solar costs. On March 1, 2017, Arizona Public Service (APS) and Solar Industry groups in Arizona reached a settlement agreement, providing more certainty for solar in Arizona. APS' original proposal sought demand charges for all residential ratepayers, elimination of retail net metering for rooftop solar and provisions a $.03/kWh rate for energy exported to the grid. In the settlement, APS rooftop solar customers who apply by June are grandfathered under current retail net metered rates for 20 years. The compensation for future rooftop solar customers would be at an export rate of $.0129/kWh (residential) – declining over a 10 year period. *(Commercial solar information was not able to be reviewed by the time this article went to press).*

The Arizona Department of Revenue in 2014 proposed property taxes on leased solar. Two of the state's largest solar providers lodged a complaint which is still under review in Arizona court. An outcome is expected later this year.

The author wishes to thank the community representatives who participated in this survey. Additionally, Arizona State University's Sustainable Cities Network and Susan Craig of WIFA provided research and assistance with this article.