The Future of Arizona Sustainability and Changing Grid Conditions

Harvard Energy Policy Group October 2, 2019

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1.8-GIGAWATTS

TOTAL RENEWABLE CAPACITY



RESIDENTIAL SOLAR PER CUSTOMER

>50%

CLEAN RESOURCES **#5** UTILITY IN NATION TOTAL SOLAR CAPACTY INSTALLED

INNOVATIVE DISTRIBUTED ENERGY PROJECTS SOLAR BATTERIES THERMOSTATS WATER HEATERS ELECTRIC VEHCILES

#3 IN NATION

MOST SOLAR PER STATE



APS Distributed Solar Market





Arizona remains a leader in residential solar energy

Figure 3.4 Installation figures for top 10 residential PV state markets, Q2 2017-Q4 2018

Installations (MWdc)	Q2 2017	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Q3 2018	Q4 2018	
California	228.6	199.8	232.0	232.0	232.6	238.7	249.8	
Arizona	50.0	<mark>50.1</mark>	<mark>51.3</mark>	<mark>55.1</mark>	40.3	38.2	50.0	
New Jersey	31.7	33.4	31.2	30.1	36.2	33.2	35.0	
New York	37.8	32.4	35.6	31.2	36.3	32.9	33.8	
Florida	15.9	13.8	15.7	21.4	23.3	26.2	27.6	
Texas	23.5	16.3	16.3	21.1	21.4	24.7	26.5	
Nevada	4.8	3.8	6.0	11.8	17.5	20.8	24.8	
Massachusetts	21.0	20.3	22.1	21.2	26.5	24.4	20.3	
Connecticut	13.1	9.9	11.0	11.4	11.3	14.0	19.9	
Maryland	37.0	24.9	24.9	13.8	18.7	16.6	16.6	

Source: Wood Mackenzie Power & Renewables

- Despite rate reforms and changes to compensation for residential solar, Arizona remains the second largest residential solar market in the U.S.
- Around 42 MWdc of residential solar was installed in Arizona in Q1 2019



APS service territory represents the majority of residential solar installed in Arizona



Sources: Solar Energy Industries Association/Wood Mackenzie Power & Renewables; U.S. SOLAR MARKET INSIGHT, 2018 year in review; Smart Electric Power Alliance – 2019 Utility Solar Market Snapshot, June 2019



APS ranked 2nd among large U.S. utilities in residential solar penetration

National ranking				2018	Total	Watts-DC of
of utilities with				Residential	Residential	residential
more than 1		Operating	Utility	Solar Capacity	Solar Capacity	solar installed
million customers	Utility Name	State	Customers	(MW-DC	(MW-DC)	per customer
1	San Diego Gas & Electric	California	1,430,144	171	972	680
2	Arizona Public Service	Arizona	1,193,542	134	710	595
3	Pacific Gas & Electric	California	5,428,594	438	2,625	484
4	Southern California Edison	California	5,049,260	318	1,969	390
	Sacramento Municipal Utility District	California	619,591	25	237	382
	Tucson Electric Power	Arizona	419,870	34	159	378
	UNS Electric, Inc.	Arizona	95,144	5	31	322
	NV Energy	Nevada	903,129	79	272	301
Other western	Rocky Mountain Power	Utah	875,094	68	251	287
utilities	Xcel Energy	Colorado	1,441,959	35	265	184
	Public Service Company of New Mexico	New Mexico	517,749	19	79	153
	Salt River Project	Arizona	1,029,543	14	153	149
	Austin Energy	Texas	464,369	10	53	113
	Pacific Power	Oregon	574,191	5	37	65

Source: Smart Electric Power Alliance – 2019 Utility Solar Market Snapshot, June 2019



Residential solar market in APS service territory remains strong under the RCP export rate structure



Number of residential solar interconnection applications received by APS per month

APS Regional Challenges





Arizona Resource Needs are Changing

- Seasonal variation of resource needs
 - Continued evening growth during high load, hot summer periods
 - Continued reduction in net load during the daytime, nonsummer periods





What does it take to reach 100% Solar Renewable Goals?

MΜ

100

50

0

- Grid used to manage import & export energy flow
- Utility must balance the grid to maintain reliability
- High solar penetration causes operational difficulties

Customer Load vs Solar Production

Import from Grid 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Hour 300 MW Solar Site --- Customer Load

100% Renewable Solar Generation

- Renewable goal increases mid-day production to nearly three times customer load
- Use of grid during all hours for load service or export



Solar Overproduction

- Renewable resources economically curtailed to ensure grid stability
- Approximate renewable curtailment in CAISO
 - 2017: 380,000 MWH
 - 2018: 461,000 MWH
 - 2019 YTD May: 630,864 MWH
- Solutions to solar overproduction
 - Energy Imbalance Market
 - Storage
 - Solar + Storage
 - Demand response
 - TOU rates
 - Customer involvement



Curtailed MWh YTD



APS is Advancing Forward Towards a Clean Energy Future

- 1. Modern Rates
- 2. Distributed Solar
- 3. Utility Scale Solar
- 4. Energy Storage
- 5. Rewards Program/DR
- 6. Microgrids
- 7. Transportation Electrification





Modern Rates Benefit Customers

Modern Rates Create

- Customer value for use that aligns to low cost time periods of service
- Integration of otherwise curtailed renewable energy
- Encourage customers shifting demand
- Smarter use of energy to integrate more renewables
- Increased opportunities in DER and DR
- Opportunity to reduce carbon emissions

Modern Rates Components

- On-Peak
- Off-Peak
- Super Off-Peak
- Demand

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Customers are Responding to Modern Rates

Residential Summer Load Profiles



Observations

- Average residential load shape for five similar Aug. & Sept. days
- Customers shifting energy from peak to 10-3 time frame
- Peak reduction
- Integration of more clean energy to grid





Rewards Programs

- DERs can have strategic value for customers and can help mitigate operational challenges on the distribution system such as voltage excursions
- DERs can provide the following values for customers and the grid
 - Demand Response (Peak Reduction)
 - Load Shift
 - Peak demand reduction
 - Solar sponge
 - Feeder congestion relief
 - Voltage support
 - Bill savings through modern rates
 - Enrollment rewards for customers
 - Annual participation awards for the Cool Rewards DR program





Cool Rewards Program

Program

- Thermostat Demand Response
- ~6,000 smart thermostats
- Up to 20 call events during the summer months
- Customer receive annual participation award

System Benefits

- Demand response load reductions during system peak events
- Participating customers can override events without penalties
- Pre-cooling strategy will shift load into hours of high solar production





Reserve Rewards Program

Program

- Water Heaters (Thermal Energy Storage)
- Customer owned water heaters operated by APS
- Shift morning usage into solar production period (while maintaining customer hot water)

System Benefits

- Reduce system peak
- load management benefits by shifting demand
- Installed on targeted feeders





Storage Rewards Program

Program

- ~40 APS owned and operated batteries
- Customer and utility share capacity

System Benefits

- Help customers shift energy usage and manage peak demand
- System peak reduction and other grid operational benefits
- Time of battery charging will be modifiable throughout year





Cool Rewards Weekday Event Results



19



What Does the Future Hold?

- Transportation Electrification
 - Take Charge AZ pilot under development
- Expansion of Customer-Facing Demand Side

Management and Demand Response Programs

- Deeper Customer Experiences through AI
 - More targeted customer messaging
 - Raising awareness of available programs