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April 23, 2018

Arizona Corporation Commission
DOCKETED

APR 23 2018

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Docket Control
Arizona Corporation Commission
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RE: Staff's Notice of Inquiry (NOI)
Review, Modernization and Expansion of the REST Rules
Docket No. E-00000Q-16-0289

Arizona Public Service Company (APS or Company) appreciates the opportunity to provide responses to Staff's NOI regarding Commissioner Tobin's proposed Energy Modernization Plan (Plan) filed in the above docket on January 30, 2018. The Plan was proposed by Commissioner Tobin as "a way to help better position our state to embrace the many changes occurring in the energy space while protecting our ratepayers and ensuring that we maintain our ability to provide clean, affordable, reliable energy for generations to come."[1]

The Plan includes an overall goal of developing an Arizona economy that, in 2050, is powered by 80% clean energy sources. Within the Plan, several additional targets and changes to existing Commission rules are outlined that are intended to support the achievement of that goal. These include plans to add biomass generating sources in the state, a Clean Peak target, extended energy efficiency and renewable generation targets, the addition of significant levels of energy storage technologies to the utility resource mix, new electric vehicle infrastructure in Arizona, and revisions to the Commission's current Integrated Resource Planning (IRP) process.

As the Commission and other stakeholders consider the Plan and its impact on the state and its jurisdictional utility customers, APS offers the following comments regarding the Plan as a whole:

The Plan must reinforce electric system reliability. It is one of APS's core responsibilities to ensure generation, transmission and distribution reliability in order to serve customers. In an age of rapid commercial technology advances, customers depend on reliable electric service as an essential component of everyday life. Arizona's energy policies must promote a future that maximizes the use of the state's resources – from baseload generation to advanced grid technologies – and must not impede the utility's ability to provide reliable electric service.

[1] Commissioner Tobin's letter dated January 30, 2018 in Docket No. E-00000Q-16-0289.

Reliability must be a cornerstone of the Plan. Existing baseload generation is facing operational challenges as more intermittent resources are being deployed. Intermittent resources themselves are facing challenges as excess energy during peak renewable hours is requiring utilities and system operators to curtail resources and offload energy to neighboring utilities whenever possible. Grid modernization efforts are critical in the continuing development of a reliable and resilient grid that can incorporate new technologies, and these efforts will also face challenges if they must compete for available funding. The Plan must maintain the reliability of the Arizona electric system over time by recognizing, considering, and addressing each of these challenges.

The Plan must consider electric price affordability. It is clear that the cost of the Plan to Arizona jurisdictional electric customers must be carefully analyzed. The issuance of this NOI is only the first step in this effort. Integrated resource plans must be developed by the utilities with Commission Staff and stakeholder input, and various scenarios should be considered to aid in the development of a sustainable Arizona energy plan. The Commission must proceed cautiously with the Plan in order to ensure that electric service remains affordable to all Arizonans.

The Plan must be inclusive. APS agrees with the Plan's interpretation of clean energy resources as being broader than simply traditionally-recognized renewable energy. The Plan includes generation resources that operate with zero net emissions as clean energy resources. This clean energy definition appropriately recognizes the Palo Verde Generating Station (Palo Verde) as an integral part of the state's ability to meet the Plan's ambitious energy goals. Palo Verde is the largest carbon-free generating plant in the country, and the only resource in Arizona that provides continuous carbon-free energy day in and day out – every day. Besides being of vital importance to Arizona, Palo Verde has also become the anchor for the entire Southwest high-voltage transmission system since it began operation in 1986. APS and the state's electric customers will rely on clean energy production from Palo Verde for the foreseeable future. The Plan will not meet its goals without the inclusion of Palo Verde as a clean energy resource.

Appendix A is a briefing document that provides information and data on Palo Verde. The briefing highlights the impact of the generating station on the citizens of Arizona and supports the Plan's inclusion of Palo Verde as a clean energy resource.

Also, as noted above, technology is advancing rapidly. Clean resources beyond energy efficiency, demand response, nuclear energy and renewable energy will emerge and will contribute to a clean energy mix. As technologies are developed that will address the challenges of a clean energy future (such as intermittent resource support, grid interoperability, and regional controls), the Plan must be able to adapt to include support of these technologies.

The Plan must be flexible. In the utility industry, as is true in all industries today, technologies are constantly being developed and deployed that will – as time progresses – change the way a utility serves its customers and change the way those customers use energy. Increasing growth of new and exciting technologies has been seen over the last ten years, and the next 30 years will likewise bring a multitude of technological advances that will have the potential to change energy production and utilization. Technologies will also be developed that will prove over time to be ineffective in supporting grid reliability and clean energy goals. The Plan must include sufficient flexibility that, if necessary, changes in timelines and goals can be adopted to recognize technological development, availability, and cost in the future. To this end, APS recommends that the Plan incorporate periodic checkpoints as safeguards to ensure the overall goal of the Plan - clean, affordable, and reliable energy for Arizona – can be met.

Development of a statewide plan is challenging, as some Arizona utilities have different jurisdictional oversight, different service territories, different sets of available resources, and different customer composition. While each utility should contribute its relative portion to a specific goal, the Plan must have sufficient flexibility that it does not impose a one-size-fits-all approach to meeting a target.

The Plan must consolidate Commission rules. Finally, as the Plan incorporates a full range of resource options, APS believes the Commission should consolidate the Electric Energy Efficiency Rules, the Renewable Energy Standard Tariff Rules, and the Integrated Resource Planning Rules into a single rule as part of the development of the Plan. This consolidation would eliminate redundancies, conflicts and contradictions between rules, and would create a planning process that recognizes all resource options must be considered jointly to create an effective, well-balanced, reliable and affordable clean energy future.

Included with this letter as Attachment 1 is APS's response to the questions Staff posed in the NOI. In the response, which is organized by the 11 major issues identified in the NOI, APS provides its reply to each issue and the accompanying questions in narrative form. Those questions within each section that request specific data are answered at the end of the section. For convenience, APS has also provided a matrix of all questions that shows where an answer to each individual question can be found (Attachment 2).

APS looks forward to discussions with the Commission, utilities and other stakeholders during development of the Plan. If any questions arise, please contact me at 602-250-3341.

Sincerely,

Kerri C

Kerri A. Carnes
KAC/bgs

Attachments

c: Elijah Abinah
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Copies of the foregoing delivered/mailed this 23rd
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Arizona Public Service Company
Responses to Staff Notice of Inquiry dated 2/22/2018
Docket No. E-00000Q-16-0289

1. Public Interest/Cost Benefit

Arizona Public Service Company (APS or Company) is committed to a clean and sustainable energy future for Arizona – and has been for years. As Arizona's leader in procuring and deploying clean and renewable resources, APS has a long history of innovative strategies to further develop clean energy. To ensure long-term diversity for Arizona, the Company plans to provide clean energy into the future through continued operation of the Palo Verde Nuclear Generating Station (Palo Verde) – which has been in operation since 1986 and has been the largest provider of carbon-free energy in the country for the last 30 years – and by adding peak-focused and trough-filling Demand Side Management (DSM) programs, renewable energy, and energy storage technologies as they become commercially viable and economically competitive. These efforts include the development of the Company's solar technology testing center in 1985, the construction of the first grid-scale solar generation in Arizona in 1997 and the recently announced innovative solar plus storage grid-scale generating facility. APS is continuing its commitment to maintaining a diverse generation portfolio to ensure customer needs are met.

APS has developed and is progressing down a path toward a cleaner, smarter energy future by integrating more renewable resources while also leading the way on the deployment of new technologies such as energy storage and microgrids. APS is moving toward a future that is not only cleaner and smarter but one that allows the Company to continue to provide customers with safe, reliable, and affordable electricity.

APS is moving toward a future that is not only cleaner and smarter but one that allows APS to continue to provide customers with safe, reliable, and affordable electricity.

Development of long-term statewide energy policies, such as the proposed Arizona Energy Modernization Plan (Plan), is challenging. To be successful, policies must meet customer needs while ensuring grid reliability, electric price affordability and sustainability. Long-term policy success also requires flexibility. For a long-term policy like the Plan, flexibility will provide participants the opportunity to leverage emerging technologies and choose a mix of technologies that is customized to meet the needs of each individual participant's customer base.

Utilities have continually adapted in response to changing customer needs, and the pace of this adaptation has only accelerated in recent years. While there are a number of available technologies that may become part of the APS resource mix, there are sure to be future technologies which the industry has yet to realize. Cost-effective energy storage is particularly critical as, without it, meeting the clean energy targets included in the Plan would be challenging.

Cost controls and checkpoints are also essential elements of a viable energy policy. In the event that technologies and costs do not develop as expected or the policy is too strictly interpreted, customer costs could become unacceptably expensive. The 32-year gap between today and 2050 is daunting under any circumstances and particularly so when factoring in the rate at which new technologies are being developed. What is envisioned as achievable today may experience challenges, unexpected detours and other unknowns before the final objective has been reached. The magnitude of this uncertainty over such a long timeframe is an added risk to Arizona's clean energy development and must be actively managed by embedding as much flexibility as possible.

The impact of the greater Southwest energy market on Arizona utilities and Arizona customers is also important to consider when developing the state's energy policy. For example, because California has aggressive and inflexible renewable energy goals, the California ISO has both curtailed renewable resources where possible and offered excess renewable generation to neighboring utilities at negative prices (that is, paying utilities to take this excess energy) during mid-day hours at certain times of the year. APS has been able to take advantage of these California policies by taking negatively-priced power for the benefit of its customers. California will continue to add more solar[1], which is expected to increasingly drive negative market prices.

Aggressive California energy storage policies may provide some mitigation but will not solve the problem entirely. A recent National Renewable Energy Laboratory (NREL) study[2] indicated that 15,000 to 28,000 MW of energy storage could be required for California to achieve 50% solar photovoltaic penetration, which would increase the already high electric prices in California. An energy policy that requires Arizona utilities to install increasing amounts of intermittent, mid-day peaking resources without checkpoints to review policy impacts could create negatively-priced energy to exist in Arizona, and therefore erase the benefit of taking negatively-priced energy from other states.

APS is analyzing the Plan and at this time has not yet completed its assessment regarding the cost and other potential impacts of the Plan. However, APS offers the following comments regarding the Plan:

- Palo Verde must continue to operate into the foreseeable future.
- Although it is still unclear what resources would comprise an APS 2050 portfolio under the Plan, by definition it would include more clean and fewer fossil resources.[3]
- APS customer electric bills would increase in the near term.[4]
- Reliability and resiliency must be of prime consideration when developing the Plan.

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[1] California Senate Bill 100 would state that it is the policy of California that eligible renewable energy resources and zero-carbon resources supply 100% of retail sales of electricity to serve California end-use customers no later than December 31, 2045, and would require the California Public Utilities Commission to promulgate rules to achieve that policy. This bill is currently in Committee at the California legislature. This bill can be accessed at https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=201720180SB100.

[2] Denholm, P. and Margolis, R. (August 2016). *Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California.* National Renewable Energy Laboratory (NREL/TP-6A20-66595). This report can be accessed at https://www.nrel.gov/docs/fy16osti/66595.pdf.

[3] It is speculative today to suggest what APS's portfolio will actually look like in 2050. If renewable energy and energy storage costs decline more than expected, APS's portfolio will naturally evolve to include more renewables and energy storage than anticipated today, and potentially include as much as under the Plan.

[4] To the extent that the Commission orders public service corporations to devote their resources towards achieving specific standards, or otherwise engaging in particular activities, public service corporations are entitled to recover any related or resulting costs, including capital costs. The same would be true for any prudent investments that have become stranded by a Commission directive.

Specific data requested in the NOI for this section:

- In addition to the over 800 MW of coal generation the Company has retired to date, APS is currently planning to reduce coal generating capacity by an additional 700 MW over the next 15 years. It is unclear at this time whether the adoption of this Plan would further reduce coal generating capacity.
- Currently, approximately 50% of the APS resource portfolio is supplied by carbon free resources, with half of that coming from Palo Verde.
- Current penetration of residential rooftop solar in the APS service territory is approximately 7%, representing 77,340 customers and 609 MWdc of installed resources at the end of March 2018. Penetration of non-residential rooftop solar is 1%, representing 1,373 customers and 306 MWdc. In total, there are 915 MWdc of distributed energy resources currently installed in the Company's service territory.
- APS's five-year history of rooftop solar installations is shown in Tables 1.1 and 1.2.

Table 1.1 Historical Penetration of Residential Rooftop Solar in the APS Service Territory

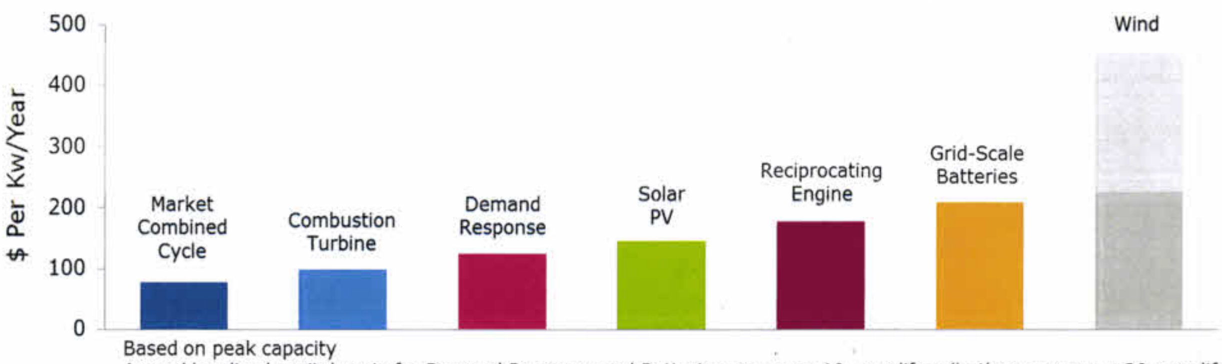
Year	Penetration	Customers	MWdc Installed
2013	2.1%	21,506	148.5
2014	2.8%	29,207	209.5
2015	3.6%	38,416	283.5
2016	5.1%	54,370	419.5
2017	6.6%	72,431	573.5

Table 1.2 Historical Penetration of Non-Residential Rooftop Solar in the APS Service Territory

Year	Penetration	Customers	MWdc Installed
2013	0.8%	1,035	226
2014	0.9%	1,164	267
2015	0.95%	1,252	277
2016	1.0%	1,300	284
2017	1.0%	1,378	297

- APS projects that penetration of rooftop solar in the Company's service territory will increase to approximately 17.3% in 2027 and approximately 18.2% in 2037.
- According to the U.S Energy Information Administration, approximately 62% of Arizona's electric customers are served by utilities that are regulated by the Commission as of the end of calendar year 2017. Salt River Project serves the majority of electric customers not served by Commission-regulated utilities.[5]
- The Solar Energy Industries Association (SEIA), in conjunction with GTM Research, reports that purchase power agreements for grid scale solar generation are now being signed at $28 to $45 per MWh.[6]
- As reported in the Company's 2017 FERC Form 1, production costs for APS's share of the Navajo Generating Station for 2017 were approximately $0.05/kWh.
- If electricity currently generated by existing baseload resources such as coal is replaced by electricity generated by newer, more expensive technologies, it can be expected that consumer prices will increase.
- Expected capital costs in 2020 for new resources are shown in Figure 1.1 below. Firm-up costs for resources with limited dispatchability have been included.

Figure 1.1 Technology Capital Costs for New Resources on a Reliability-Equivalent Basis



Based on peak capacity
Annual levelized capital costs for Demand Response and Batteries assume a 10-year life; all others assume a 20-year life
Solar PV assumes inclusion of Investment Tax Credit (ITC)

2. Policy Framework

The Plan proposes, at its core, the development of an Arizona economy that is powered by an energy mix that would include 80% clean resources by the year 2050. Within this overall proposal, additional targets and changes to existing Commission rules are outlined which are intended to support achievement of the Plan. As the NOI notes, the Plan

[5] U.S. Energy Information Administration's EIA-861M (formerly EIA-826) database, accessible at https://www.eia.gov/electricity/data/eia861m/index.html
[6] SEIA Solar Industry Research Data, accessible at https://www.seia.org/solar-industry-research-data. These prices reflect non-curtailable solar array costs and include impacts of ITCs.

proposes to use the current Renewable Energy Standard and Tariff (REST) rules as the foundation for a broader, more inclusive framework for modernizing energy policy.

However, achievement of an Arizona energy mix of 80% clean energy resources will require changes – in some cases, substantial changes – in other existing Commission rules and policies in addition to the REST. Specifically, the Energy Efficiency Standards rules and the Integrated Resource Planning rules are the two additional Commission policies that appear to require significant change in order to effectively support the Plan.

The Electric Energy Efficiency Rules, the Renewable Energy Standard Tariff Rules, and the Integrated Resource Planning Rules should be consolidated into a single rule.

APS believes the Electric Energy Efficiency Rules, the Renewable Energy Standard Tariff Rules, and the Integrated Resource Planning Rules should be consolidated into a single rule as part of the development of the Plan. This consolidation would eliminate redundancies, conflicts and contradictions between rules, and would create a planning process that recognizes all resource options must be considered jointly to create an effective, well-balanced, reliable and affordable clean energy future.

As the Commission, utilities, and other stakeholders move forward with the development of the underlying policy changes that will be required to implement the Plan, answers for many of the questions posed in the NOI will be discussed and resolved. The role of merchant generators, natural gas transmission providers, natural gas storage, electric cooperatives, technology providers, and other Arizona energy entities will become clearer as the Plan is more fully developed. The factual record that will be developed in the course of creating the Plan will assist the Commission in creating policy change. It appears clear, though, that in the event some Arizona utilities and energy providers are not included in the Plan, overall targets should be redefined to reflect the relative portion that should be assigned to each included provider.

Development of a policy framework underlying the Plan is certainly within the Commission's discretion, and this framework can be shaped to achieve a number of policy objectives. The management interference doctrine, however, does provide some limitation to the policies the Commission can adopt. Arizona law draws the distinction between Commission rules that attempt to control the operation of corporations, which are not permitted, and rules that attempt to control rates, which are permitted. Adherence to this doctrine will need to be considered carefully as the Plan moves forward.

With regard to the changing role of utilities in response to market and technological change, utilities have continually adapted in response to changing customer needs, and the pace of this adaptation has only accelerated in recent years. APS's efforts to adapt are evident in its focus on building and maintaining an enabling grid, one that facilitates customer choices while preserving the reliability that customers require. APS seeks to ensure that clean energy itself is sustainable. The Company's long-term business strategy supports the adoption of cost-effective clean energy, and achieving this outcome will require updating physical facilities and refining operational practices.[7]

3. Clean Energy

By today's standards, 80% clean energy is an aggressive target. Given that the technology to achieve these goals is not yet cost-effective in most instances, the target could impose high costs on customers. There also needs to be sufficient flexibility in the timeline for implementation to allow for adequate technology development, in the event that costs are deemed too high periodic checkpoints should be established in order to protect customers from unacceptably high rate increases.

Implementing the Plan as a target rather than a standard allows clean energy goals to be met while maintaining reliability and affordable costs for customers.

The Plan should establish a target, rather than impose a standard, that can be met by both existing and new clean resources. It should include nuclear generation, DSM that is load-reducing, load-building and load shifting, renewable generation, energy and capacity from energy storage devices and be flexible enough to allow for potential new technologies. All forms of clean energy should be counted if used by APS customers whether it is utility-scale or distributed. Distributed Energy Resources (DER) should be measured by kWh, not Renewable Energy Credits (RECs), as is required today in the REST rules.

The NREL study[8] referenced in the NOI is instructive for identifying any potential issues related to high renewable development, but it should not be used to set state-wide policy on renewable electricity. This study was high level and did not attempt to review reliability scenarios or perform a detailed cost-benefit analysis. It also did not address institutional, market, and regulatory changes that may be needed to facilitate its suggested transformation to 80% renewable generation nationwide by 2050. Technology cost assumptions may have been reasonable at the time the study was done; however, cost assumptions have changed dramatically since then. The simulation in 2050 for example resulted in 22,000 MW of Concentrated Solar Power (with six hours of storage) and over 8,700 MW of wind being installed in Arizona while Palo Verde was operating at 24% capacity factor. These results are unrealistic for Arizona. NREL has continued to perform renewable energy penetration studies; however, to APS's knowledge, they have not updated the 2012 study. APS is not aware of critiques or on-going reviews of the 2012 study. If these types of studies are desired for the state of Arizona, they should take place in respective utility Integrated Resource Plan (IRP) process.

Nuclear power is vitally important to clean energy and the Arizona economy, and it must be counted towards meeting the Plan's targets. While not considered renewable, nuclear power is clean; it emits no greenhouse gases or other emissions that contribute to air

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[7] In APS's most recent rate case, Executive Vice President of Operations Daniel Froetscher discusses APS's sustainable energy vision. Direct Testimony of Daniel T. Froetscher, Docket No. E-01345A-16-0036, June 2016. This testimony can be accessed at http://images.edocket.azcc.gov/docketpdf/0000170848.pdf.

[8] National Renewable Energy Laboratory (2012). *Renewable Electricity Futures Study* (NREL/TP-6A20-52409). The Executive Summary of this report can be accessed at https://www.nrel.gov/docs/fy13osti/52409-ES.pdf.

pollution. In 2017, Palo Verde produced 32.3 million MWhs of clean energy that supplied power to Arizona, as well as Texas, California and New Mexico. This is the largest carbon-free, clean energy resource in the country. The consequences of not counting nuclear would be adverse and dramatic. If Palo Verde is not counted toward the goal, significantly more renewable generation would be required that would challenge the real-time operations of Palo Verde, likely resulting in the early shutdown of the plant. Based on an independent economic impact analysis completed in 2017, Palo Verde created an economic impact in the state of Arizona of more than $2.1 billion in 2016, and will create an impact of $10.6 billion in Arizona over the years from 2017 through 2021.

Nuclear power is vitally important to clean energy and the Arizona economy.

The Palo Verde units are licensed to operate until 2045, 2046, and 2047. They have already received 20-year extensions of their original operating licenses, and could potentially receive another round of extensions that would extend their lives into the mid-2060s. There are no known technical issues that would prevent those extensions, and the plant is currently upgrading control systems (from analog to digital). APS does not currently anticipate any extraordinary costs associated with keeping Palo Verde operational beyond 2045. Nuclear plant operators in the U.S are actively engaged with the NRC to develop the regulatory processes to support a second round of license renewals.

New nuclear generation could potentially be available in the late 2020s to 2030s. Small Modular Reactors (SMRs) are currently under development, and will be designed to be smaller and more flexible than traditional nuclear plants. APS will continue to follow development of this technology, but at present, SMRs are not a commercially mature technology or economically viable option.

Existing as well as potential new nuclear generation should be counted toward meeting the Plan's targets. However, to ensure flexibility in implementing the Plan, there should be no technology specific mandates.

Specific data requested in the NOI for this section:

- APS is aware of several studies and scientific papers that discuss the possibility of reduced water usage due to clean resource goals.[9] It is important to note that APS has not reviewed these studies in depth and at this time cannot either endorse or refute the calculations or conclusions reached.

[9] Environmental Science & Technology, "Consumptive Water Use from Electricity Generation in the Southwest under Alternative Climate, Technology, and Policy Futures" (2016). This report can be accessed at https://cedmcenter.org/wp-content/uploads/2017/10/Consumptive-Water-Use-from-Electricity-Generation-in-the-Southwest-under-Alternative-Climate-Technology-and-Policy-Futures.pdf ; Sandia National Laboratories, "Water Use and Supply Concerns for Utility-Scale Solar Projects in the Southwestern United States" (July 2013). This report can be accessed at http://prod.sandia.gov/techlib/access-control.cgi/2013/135238.pdf ; U.S. Department of Energy, University of California, "Capturing the Benefits of Integrated Resource Management for Water & Electricity Utilities and their Partners" (May 2016). This report can be accessed at https://www.energy.gov/sites/prod/files/2016/06/f32/Capturing%20the%20Benefits%20of%20Integrated%20Resource%20Management%20for%20Water%20%26%20Electricity%20Utilities%20and%20their%20Partners.pdf ; IOP Publishing, Environmental Research Letters, "Modeling low-carbon US electricity futures to explore impacts on national and regional water use" (January 2013). This report can be accessed at http://iopscience.iop.org/article/10.1088/1748-9326/8/1/015004 ; IOP Publishing, Environmental Research Letters, "The influence of future electricity mix alternatives on southwestern US water resources" (January 2013). This report can be accessed at http://iopscience.iop.org/article/10.1088/1748-9326/8/4/045005.

4. Energy Storage

Energy storage is a rapidly growing segment of the utility industry, and APS has already started to integrate storage into the grid. However, energy storage is also a relatively new technology with limited performance history, and therefore, a statewide target for energy storage must be considered carefully.

Mature storage technologies are still above the costs of other conventional resources.

Given current data and forward looking forecasts, APS considers the attainment of a 3,000 MW statewide goal of energy storage to be an aggressive yet potentially attainable goal over the long term. It is not currently clear that this goal can be achieved without causing an increase in electricity rates for APS customers as storage technologies are typically still above the costs of other conventional resources. The point at which these technologies will cross the cost-effectiveness threshold is difficult to predict; however, there are a number of third party forecasts that can be utilized in order to form an estimate. In APS forecasts, storage resources may become cost-competitive with conventional peaking resources around 2025 based on cost-reduction forecasts provided by IHS in their late 2015 report entitled *"Grid-Connected Battery Storage Forecast in North America, 2015–30"*. [10]

A general survey of storage technologies reveals that while there are a great number of technologies in active testing and development, only a few have risen to the level of maturity that could be meaningfully considered for the proposed 3,000 MW goal. APS's NOI response is primarily focused on these technologies. A working definition of whether a storage technology is mature is whether it has: 1) been deployed globally at a volume of 100 MW or greater in a single project in a bulk electric-system capacity, and 2) attracted debt financing in a non-recourse project financing structure.

Technologies that meet these criteria include:

- Pumped hydro;
- Thermal storage (Molten salt storage in a thermal-to-electric system);
- Compressed air energy storage (CAES); and
- Lithium-ion battery.

CAES is a proven technology and two large projects have been operating reliably for over 25 years. However, the installed base is small due to the requirement of natural or man-made air storage caverns/vessels. Arizona has a number of salt basins which may be utilized to develop caverns for CAES.[11]

An emerging storage technology that has the potential to cross the maturity threshold for bulk utility consideration is the flow battery. An attractive feature of flow batteries is their ability to serve for longer durations (> 6 hours) and longer lifespans (typically 20+ years). In comparison, Li-ion batteries are typically rated to last 10 years. Please see Tables 4.1 through 4.3 for statistics related to each of these technologies.

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[10] IHS Technology (2015). Grid-Connected Energy Storage Report. This report was purchased by APS and is governed by terms and conditions of the purchase. Please contact APS for access to this document.

[11] Rauzi, S.L. and Neal, T.J. (1996). Storage Opportunities in Arizona Bedded Evaporites. Arizona Geological Survey Open File Report (OFR-96-27). This report can be accessed at http://repository.azgs.az.gov/uri_gin/azgs/dlio/815; Rauzi, S.L. (2002). Arizona has Salt!. Arizona Geological Survey, Circulars (C-30). This report can be accessed at http://repository.azgs.az.gov/uri_gin/azgs/dlio/1075.

A 3,000 MW energy storage target for 2030 is technically feasible with a wide variety of storage technology options available that have been proven to work at large scale, but reaching the 3,000 MW goal will require concerted efforts from Arizona utilities to develop multiple large scale (50-250 MW), long duration storage projects over the 12-year period, and may result in increased customer rates. With respect to whether interim targets are needed to achieve a 3,000 MW goal, this is a matter of public policy.

APS continually evaluates areas of its system where energy storage technology may provide system benefits commensurate with their costs. Assuming price projections for this resource continue to decline, it is likely that APS will, through the request for proposal (RFP) process, procure additional storage resources by 2030 with much of the capacity coming online during the 2025-2030 timeframe. Looking further out, energy storage is forecasted to become progressively useful to help manage evolving load shapes, provide system support and further diversify clean energy portfolios. Based on this outlook, APS anticipates that energy storage contributions to the Company's overall portfolio mix will grow over time.

Specific data requested in the NOI for this section:

- For installed resources, APS currently has 256 MW of electric storage under contract or direct ownership in its service territory. The majority of APS storage capacity is in the form of 250 MW x 6 hours of utility-scale storage under a power purchase agreement (PPA) with the Solana Generating Station, which has been in operation since 2013. Solana provides bulk electric storage to the APS system in the form of molten salt coupled with solar parabolic trough technology. In addition to Solana, APS has three grid-scale, lithium-ion battery installations, which it owns and operates. The Punkin Center battery project also deferred an upgrade of 16.5 mile 21 kV circuit that serves the town. APS also has two smaller, residential battery storage programs in active development.

- In 2018, APS announced the execution of a 50 MW / 135 MWH (storage) x 65 MW (solar) PPA with First Solar, which was contracted under the 2017 peaking RFP. This project is scheduled to be online in 2021.

- The following tables provide specific data on storage technologies.

Table 4.1 Storage technologies suitable for large scale storage plants

Technology	Capacity of Largest Plant with Long Duration (≥4 hr) Storage[1]	Global Installed Capacity[1]
Pumped Hydro	3,003 MW	169,557 MW
Thermal Storage	360 MW	2,809 MW
Compressed Air Energy Storage (CAES)	290 MW	406 MW
Lithium-ion Battery	30 MW	1,510 MW
Flow Battery	15 MW	47 MW

[1] DOE Global Energy Storage Database; accessible at https://www.energystorageexchange.org/
NOTE: Size of operating plant indicates the scalability of the technology, while installed capacity indicates the adoption of the technology by the utility industry.

Table 4.2 Capital cost of large scale storage technologies

Technology	Capital Cost of Energy ($/kWh)	Capital Cost of Capacity ($/kW)
Pumped Hydro	213-313[1]	1,700-5,100[3]
Compressed Air Energy Storage (CAES)	130-188[1]	1,300-2,800[3]
Lithium-ion Battery	335-425[2]	1,338-1,770[2]
Flow Battery	313-713[2]	1,252-2,850[2]

[1]Lazard (December 2016). Lazard's Levelized Cost of Storage - Version 2.0. The report can be accessed at https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf.
[2]Lazard (November 2017). Lazard's Levelized Cost of Storage - Version 3.0. The report can be accessed at https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf.
[3]Electric Power Research Institute (EPRI) (November 2016). Energy Storage Cost Summary for Utility Planning (3002008877). The Executive Summary of this report can be accessed at https://www.epri.com/#/pages/product/3002008877/

Table 4.3 Energy conversion efficiencies of large scale storage technologies

Technology	Energy Conversion Efficiency at System Level
Pumped Hydro	76-85%[1]
Compressed Air Energy Storage (CAES)	64%[2]
Lithium-ion Battery	~85-90%[3]
Flow Battery	60-75%[3]

[1]Akhil, A.A. *et.al.* (July 2013). DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA. Sandia National Laboratories (SAND2013-5131). This report is accessible at http://www.sandia.gov/ess/publications/SAND2013-5131.pdf.
[2]The Arizona Research Institute for Solar Energy (AzRISE) (August 2010). *Study of Compressed Air Energy Storage with Grid and Photovoltaic Energy Generation*. University of Arizona. This report can be accessed at http://u.arizona.edu/~sreynold/caes.pdf.
[3]Vendor-provided specifications on lithium-ion and flow battery performance.

5. Forest Health/Biomass-Related Energy

APS supports the evaluation of initiatives that can improve the lives and safety of Arizona residents and efforts that could lead to healthier forests. Benefits of forest thinning include reduced risk of catastrophic wildfire and watershed improvement. These benefits accrue to all Arizonans.

APS was at the forefront of Arizona biomass energy production when in 2008 it purchased approximately half of the output of the 27 MW Novo Biopower plant, which has enabled up to 15,000 acres per year of forest thinning. APS plans to continue this leadership and will issue multiple RFPs in the next several months as part of a comprehensive effort to meet its resource needs beginning in the early 2020s. APS will seek competitive proposals for Arizona forest bioenergy solutions, as well as peaking-capacity needs, and battery retrofit opportunities for APS-owned solar facilities. More specific information about each of the solicitations will be released in the coming weeks.

The benefits of forest thinning accrue to all Arizonans.

A bioenergy requirement will increase the cost of electricity for Arizona customers. In a report filed in November 2017, APS evaluated three bioenergy scenarios – low-, medium- and high-use of the resource.[12] On a statewide basis, the amount of bioenergy represented in the Plan is equivalent to the medium-use scenario. Based on the preliminary estimated costs of a new bioenergy plant and allocating all of the costs to APS customers, the report indicated that the average residential customer's bill would increase by $2.57 per month in 2021. By spreading costs over all Arizona customers and reducing the cost of the bioenergy plant itself,[13] APS residential customer cost could potentially be reduced to under $1.00 per month.

In the report, it was assumed that the bioenergy plants were located close to existing APS transmission lines and that the new facilities would not trigger the need for transmission upgrades. To the extent that new facilities require new transmission lines or require wheeling over third party lines, additional costs would be incurred. The cost of new transmission is based on the length of the line and terrain considerations, while the cost of wheeling would be charged according to the transmission owner's Open Access Transmission Tariff (OATT). In the event that the transmission owner does not have an applicable OATT on file with FERC, a rate would need to be developed and negotiated.

APS contracted with Black & Veatch (B&V), a consulting agency with expertise in bioenergy systems and services, to conduct a technical assessment and attached that assessment as an appendix to the APS report.[12] According to B&V, preliminary engineering, permitting and construction of a bioenergy facility can take four or more years. The Plan requires the new bioenergy plant to be in service by 12/31/2021. It may not be possible to get such a facility in service by the end of 2021, and APS therefore recommends that the in-service date be extended accordingly.

Specific data requested in the NOI for this section:

- The Novo Biopower PPA expires in June 2023 and APS has not yet determined whether it will extend the contract.
- As reported in the Company's 2017 FERC Form 1, the cost of power from the Novo Biopower PPA in 2017 was approximately $0.098/kWh.

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[12] In compliance with Decision No. 76295 (August 18, 2017), in Docket No. E-00000Q-17-0138 APS filed a report with the Commission entitled, "APS Forest Bioenergy Report." This report can be accessed at http://images.edocket.azcc.gov/docketpdf/0000184242.pdf.
[13] Reduced bioenergy cost based on re-locating existing shuttered bioenergy plant to Arizona instead of new construction.

6. Dispatchable Clean Energy

Clean sources available to meet a Clean Peak Target (CPT) include nuclear, renewables, DSM and energy storage.

In Arizona, nuclear is already an important part of the energy mix. Solar has significant growth potential but only produces during part of the peak load hours. As a result, a growing CPT could predominantly be met by solar plus energy storage sources as energy storage would be required to ensure dispatchability and curtailability of solar resources. However, behind-the-meter DERs and energy storage systems under customer control do not provide the same CPT grid benefits as systems managed by the utility. Rate modernization and the alignment of system wholesale prices for capacity and energy is one tool that can help align the dispatch of customer-sited resources with bulk and local electric system needs.

APS Clean Peak Target resources would be predominantly solar plus energy storage.

Separately, some utilities are experimenting with aggregating behind-the-meter (BTM) storage resources and making them available for direct utility control, which is referred to in the industry as BTM aggregation. One challenge associated with BTM aggregation of storage resources is to properly account for system costs and benefits. A grid-tied asset just in front of a customer's meter will always be available for direct utility control; however, BTM assets may not always be available depending on customer usage on a given day. A final element worth commenting on is the need for a Distributed Energy Resource Management System (DERMS) to better coordinate dispatchability of distributed assets to help achieve CPT targets. This type of control system is a new and rapidly evolving platform that is still in development through collaboration of utilities and technology companies.

While energy storage could help manage the duck curve and baseload impacts, APS does not see an inherent benefit in meeting specified peak load hours with clean energy versus meeting other load hours with clean energy. On-peak emissions are no different than off-peak emissions, especially from a greenhouse gas perspective. In the near term, batteries may or may not be the most cost-effective way to reduce demand during peak load hours; depending on technology improvement and cost reductions this will change in later years. While batteries provide for some level of dispatchability, they are limited by the amount of storage capacity. Actual cost-effectiveness should be determined through the competitive procurement process, consistent with the Commission's established procurement rules.

To the extent that the use of battery storage can level out the operation of fossil generation including "rapid cycling" of gas turbines, air emissions could potentially be reduced by some small amount. In any event, APS operates its power plants within the limits of the air permits, and has not estimated whether or not or by how much the adoption of a CPT would impact air emissions.

While APS supports the use of clean energy, it appears that the intent of the CPT may already be met by the energy storage target contained in the Plan. The energy storage target is simpler to administer since it can easily be tracked by counting MWs installed. The CPT is more difficult to administer. It appears to be the intent of the Plan to include DSM in the target.

7. Energy Efficiency

Since the implementation of APS's initial experimental time-of-use (TOU) rate in April of 1976, the Company has encouraged its customers to take action to reduce the amount of energy used in homes and businesses. Over the years, APS has developed various DSM programs to help customers manage monthly energy bills, and to allow the Company to effectively manage the capacity and energy needed to meet growing customer demand for electricity. DSM programs fall into two categories: energy efficiency programs, whose goal is to encourage customers to use less electricity in all hours of the year by being more efficient in how that electricity is used; and demand response programs, whose goal is to promote less energy usage specifically in those hours when the demand for electricity is at its highest.

Although the Commission's existing rules are labeled "Energy Efficiency" rules, they recognize the ability of demand response programs to contribute to overall energy reduction targets. However, there remains a limitation on how much demand response can be counted toward the standard. As the Commission considers implementation of the Plan, this limitation must be eliminated to allow all clean resources to be equally counted toward any targets that may be developed.

This broader interpretation will not only allow demand response efforts to contribute to the Plan's goals, it will also promote programs designed to reduce peak and fill daytime "trough" hours – which will also contribute to meeting long-term energy goals by managing the impact of intermittent resources. Programs that utilize negatively priced energy and advanced technologies and analytics that assist customers to optimize energy use can also be included under this definition.

APS proposes a MW Managed goal to better reflect the DSM portfolio as a resource.

In line with a more comprehensive concept of energy efficiency, APS proposes a "MW Managed" goal, where MW Managed is any MW that meets a defined resource need. The MWh reduction goal that currently exists in the energy efficiency rules no longer reflects the needs of Arizona utilities and Arizona consumers because the MWh goal encourages conservation of energy during times the marketplace is already curtailing solar resources and paying market participants to take negatively priced energy, exacerbating excess resources.

APS plans resources to support affordable, reliable electric service for how and when customers use electricity. Arizona's economic growth and customer adoption of solar resources will continue to (i) increase demand during the summer peak and (ii) reduce demand during the mid-day of non-summer months. The Commission has recognized this, stating that APS's focus should be on reducing peak energy use and demand, as well as shifting energy use away from peak times to off-peak times.[14]

This recognition takes a more holistic view of DSM and correctly treats the DSM portfolio as a resource. Energy efficiency that targets peak savings can still have a prominent role; however, in conjunction with modern rates, smarter energy use will provide savings opportunities for customers that align with reducing demand during peak and shifting energy use to off-peak times of the day. Programs that encourage and educate regarding

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[14] *See* Decision No. 75679 (August 5, 2016).

energy use and savings opportunities with modern rates can show positive impact on the grid while adding customer value, and should be counted towards any clean energy targets.

As DSM is now focused on education and smart use of technology, program assessment of cost-effectiveness should also be modified. The existing rules use the societal cost (SC) test to evaluate DSM programs. This test does not consider the transfer of payments from DSM program participants to non-participants through the ratemaking process. Transfer payments take the form of rebates directly paid by APS to the participating customers as well as the bill savings they receive. Because of this, the SC test should be considered one of several measures of DSM program effectiveness rather than a single, stand-alone test. From a planning perspective, a more practical form of the SC test - the Total Resource Cost (TRC) test - should be used. From a rate perspective, the Ratepayer Impact Measure (RIM) test is also necessary as it evaluates a program's impacts on non-participating customers – i.e., the shifting of cost assignment from participating customer savings to non-participating customers. As such, both the TRC and RIM tests are helpful and should be used in developing long-term DSM plans as part of customer-side resources.

Due to the emergence of grid-scale and rooftop solar generation, APS's resource needs have changed in recent years. DSM is a resource, and for a long-term energy plan to be effective, it should be included in any future resource plans. It should have goals and effectiveness tests that reward meeting those resource needs while also limiting the impact to non-participating customers. Great strides have been made to bring DSM technology to market. With these technologies now commonplace, an educational focus will have the most impact on energy use. DSM can be an effective resource which educates and rewards customers for using energy in conjunction with modern electric rate design and in alignment with system needs.

8. Electric Vehicles

The Commission has a long history of supporting consumer adoption of electric vehicles (EVs) in Arizona. In 2009, the Commission directed APS to conduct a vehicle-to-grid feasibility and cost-benefit study and propose a vehicle-to-grid program for Commission consideration.[15] The Commission also approved an APS pilot program in 2011 that was designed to help raise awareness of the benefits of and availability of EVs, and to support customer EV adoption in the Company's service territory as well as consider how these vehicles would interface with the utility electric grid.[16] APS agrees that a robust EV market in the state of Arizona will contribute to the overall goals of the Plan.

Traditionally, the benefits of EV adoption were mostly attributed to individual customer vehicle fuel and maintenance savings, along with emission reductions when compared to gas-fueled vehicles. Utilities have developed specific rate schedules with specific low-cost off-peak hours – these have exclusively been night off-peak hours to date – to provide individual customer electric bill savings as a measure to promote EV adoption and to prevent vehicle charging during peak demand hours. For APS, with nearly 60% of

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[15] This study was provided to the Commission in Docket No. E-01345A-10-0123. APS retained Navigant Consulting to prepare the report, and its overall conclusion was (at the time of the report in March of 2010) that vehicle-to-grid services were currently at the research and pilot stage, and none of the concepts reviewed were commercially viable. Navigant Consulting, *PHEV/EV and V2G Impacts and Valuation Study*, March 2010. The study can be accessed at http://images.edocket.azcc.gov/docketpdf/0000109132.pdf.
[16] This pilot program was approved in Decision No. 72582 (September 15, 2011).

residential customers on time-of-use rates, this traditional method of promoting EVs has proven to be successful in the past.

EVs also provide meaningful carbon emission reductions. While the U.S. Department of Energy reports a 63% reduction in pounds of CO_2 equivalent from all-electric EVs charging in Arizona as compared to a gasoline vehicle,[17] the more meaningful benefit is that all-electric EVs have zero tailpipe emissions.

However, the potential benefits of EVs extend beyond customer savings and emission reduction. If utilities, policymakers, and other stakeholders are successful in promoting increased customer adoption of EVs and concurrently successful in promoting strategic charging behavior, EVs could also contribute to an increased utilization of grid infrastructure and might assist in the absorption of excess regional renewable generation. As noted in the Plan, EVs may in the future become a tool to assist utilities in absorbing excess daytime solar production if policies are successful in changing the traditional customer expectations for nighttime charging. For all these reasons, APS today includes consideration of these vehicles and their impact on the electric system when it develops its resource plans.

The cost of implementing EV infrastructure on a broad scale is difficult to determine without consideration of a specific program because those costs vary greatly by application, size, location, and sophistication of charger. EV charging infrastructure is typically classified by power supply. Variations in power supply translate to differences in charging times and power demands on the system. The most common charging stations are Level 2 chargers. Level 2 chargers are used in residential homes, fleet, workplace, and many other charging applications.

DC Fast Charging costs ranges significantly based on location and availability of power. DC fast chargers are being deployed with as much as 320 kW of power. The draw on the system can create variations in cost that can be significant due to the potentially remote location development with inadequate local distribution facilities needed to serve the location.

APS supports utility ownership of EV charging infrastructure.

APS supports utility ownership of electric vehicle charging infrastructure. The Managed Electric Vehicle Charging Pilot Program submitted as part of the APS 2018 DSM Implementation Plan envisions an expanding EV market and includes programs which would allow for utility ownership. The pilot program includes several measures designed to survey and measure results for EV adoption in the APS service territory, and aims to bring the benefits of EVs to participating customers in the most efficient manner for the electric system to maximize benefits for all APS customers. The proposed program consists of APS owned, operated, and managed EV charging infrastructure designed for three different non-residential applications:

1. Commercial fleet vehicle charging;
2. Workplace charging stations for employees vehicles; and
3. Multi-family charging stations.

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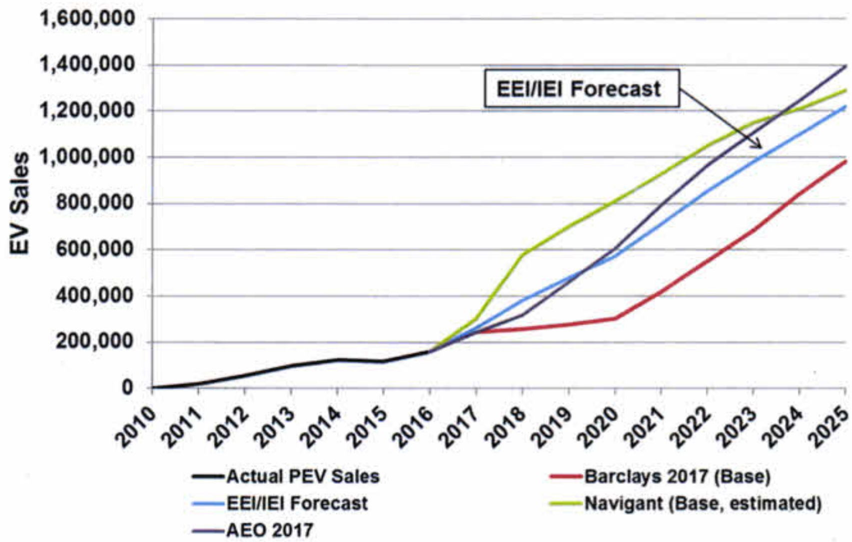
[17] U.S. Department of Energy. Energy Efficiency & Renewable Energy's Alternative Fuels Data Center, Emissions from Hybrid and Plug-In Electric Vehicles. This information can be accessed at https://www.afdc.energy.gov/vehicles/electric_emissions.php.

The program is designed to provide customers an opportunity to maximize the benefits of innovations in EV technology that continue to bring longer vehicle range at reduced prices to consumers. Charging times for the program are designed to be scheduled and managed to avoid customer, distribution and system level peaks. APS has proposed an experimental rider designed to charge customers who participate in the Managed Electric Vehicle Charging Pilot Program.[18]

Electric vehicles continue to grow in market share. Although electric vehicles comprised less than 1% of 2017 vehicle registrations, that is an increase of over 33% from 2016 EV registrations. EV adoption is expected to increase in the future as battery technology improves and a wider range of vehicle models becomes available. Figure 8.1 below shows historical adoption data as well as comparative forecast adoption rates from several sources.

Figure 8.1 Annual EV Sales by Year (2010 through 2025)



Cooper, A. and Schefter, K. (June 2017). Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required. Edison Electric Institute. This report can be accessed at http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20%282%29.pdf.

Specific data requested in the NOI for this section:

- There are several sources of information and data on state and utility level electric vehicle programs and incentives. One of these, the National Conference of State Legislatures (NCSL), has developed an interactive webpage which provides a

[18] A complete description of the proposed program is available in APS's Application for Approval of 2018 DSM Implementation Plan, filed September 1, 2018 in Docket No. E-01345A-17-0134. The Application can be accessed at http://images.edocket.azcc.gov/docketpdf/0000183906.pdf.

comprehensive catalog of electric vehicle incentives available in each state.[19] The North Carolina State University Clean Energy Technology Center issues a quarterly report titled "The 50 States of Electric Vehicles," which provides insights on state regulatory and legislative discussions and actions on electric vehicles and charging infrastructure, along with listings of available programs.[20] Additionally, the Energy Information Administration (EIA) issues an Annual Energy Outlook report which addresses electric vehicle adoption rates and provides future projections.[21]

- A comprehensive list of federal incentives, laws and regulations, programs and other funding opportunities and initiatives is available from the U.S. Department of Energy's Energy Efficiency and Renewable Energy Office through EERE's Alternative Fuels Data Center.[22]

9. Resource and Transmission Planning

During the next 32 years, energy and transmission resources, customer usage patterns, and location of load will change, often in unforeseen ways. The Plan, together with associated planning rules, should be flexible enough to accommodate those changes.

To ensure that a consolidated energy modernization rule is structured to maximize the potential for meeting the Plan's targets, the following elements should be incorporated in the planning process:

Effective rules are anchored in sound planning principles. The principles of reliability, affordability, flexibility and sustainability should continue to guide both planning and implementation efforts. Given that the Plan has sustainability as a core objective, the remaining three principles should be formalized as equally important within the state's resource planning framework by including the provision that a clean energy future can only be attained within the parameters of a utility's commitment to provide reliable, affordable energy to its customers.

In order to meet the Plan, utilities must undertake comprehensive planning efforts. To that end, the Commission should consolidate the Electric Energy Efficiency Rules, the Renewable Energy Standard Tariff Rules, and the Integrated Resource Planning Rules into a single rule. Having a single process to evaluate all resources would provide greater comparative value, assist in the evaluation of how resources interact over time and present a unified long term plan toward a cleaner energy future.

One exception to this is the Biennial Transmission Assessment (BTA) process which should remain separate from a consolidated rule due to:

1. Its planning horizon is 10 years, while the IRP's is 15 years.
2. Its focus is on reliability, while the IRP encompasses a more comprehensive approach including the principles delineated above.

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[19] The NCSL webpage can be accessed at http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx.
[20] The 50 States of Electric Vehicles quarterly report is available at https://nccleantech.ncsu.edu/nccetc-launches-the-50-states-of-electric-vehicles-quarterly-report/.
[21] The 2018 EIA Annual Energy Outlook can be accessed at https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf.
[22] The Alternative Fuels Data Center federal programs list can be accessed at https://www.afdc.energy.gov/laws/fed_summary.!

3. Its process is geared towards coordination with a broader range of transmission providers, not all of which will be working towards the Plan's 2050 goal.

The concept of clean energy should be as inclusive as possible: APS agrees with the Plan's broad interpretation of clean energy and particularly highlights the need to maintain the classification of nuclear energy as a clean resource as the state works towards the Plan's 2050 target. Furthermore, as technologies advance, other clean resources beyond DSM, nuclear and renewable energy will increase their contribution to the energy mix and will be relied upon more extensively. Cost-effective energy storage will play a pivotal role in Arizona reaching a target of 80% clean energy goal by 2050.[23]

The Plan must include sufficient flexibility that, if necessary, changes in timelines and goals can be adopted to recognize technological development, availability, and cost in the future.

Cost burdens to customers must be minimized: The pursuit of a clean energy future, even while anchored in the principle of affordability, may increase costs to customers. Any disparities in adherence to the Plan across the state's utilities will result in similar disparities in electric rates among service territories – unduly disfavoring some regions of Arizona over others. Consolidated rules should allow for forms of customer cost containment to ensure that Arizona's value as a state for future commercial and industrial development unfolds as uniformly as possible.

Periodic checkpoints should be incorporated as safeguards in consolidated rules: The 32-year gap between today and 2050 is daunting under any circumstances and particularly so when factoring in the rate at which new technologies are being developed. What is envisioned as achievable today may experience challenges, unexpected detours and other unknowns before the final objective has been reached. The magnitude of this uncertainty over such a long timeframe is an added risk to Arizona's energy development and should be actively managed by embedding as much flexibility as possible and mitigating efforts in the Plan's resource planning rules at the onset. Periodic checkpoints will monitor compliance with the Plan's overarching goals, while ensuring each utility's plan is serving the best interest of its customers.

APS believes the Action Plan, as it exists today, provides the Commission with sufficient review of updates to a utility's IRP or resource decisions between IRP cycles. The pre-filing IRP workshops, Open Meetings and other pre-filing communications are mechanisms that are in place for utilities to request further direction if needed. Furthermore, the Plan's target of 80% clean energy by 2050 provides sufficient scope for utilities to procure resources that will meet load while also working towards the statewide goals established by the Plan.

10. Process-Related Issues

To the extent that the Plan might change, overwrite, or otherwise directly affect the outcome of another open docket, efficiency would suggest that those open dockets be consolidated with the docket in which the Plan is being considered. This would afford maximum notice to interested stakeholders and limit further activity in related dockets that could be duplicative or even inconsistent, and may cause unnecessary duplication of

[23] Energy storage needs to receive the same consideration that demand response receives under the current energy efficiency rules.

resources. In addition, developing the Plan in multiple dockets might discourage participation by interested parties that typically do not engage in Commission-related rulemakings. Moreover, to the extent that the various facets of the Plan rules overlap or rely upon one another, a single docket appears to be appropriate. The Commission might find it useful, however, to create a phased proceeding in which specific issues are identified and resolved so that parties interested in only specific issues need not be required to stay abreast of every development.

Because the Plan could have broad and sweeping implications for Arizona, APS expects a wide range of stakeholders will be interested in participating in development of the Plan. The Commission may wish to permit intervention broadly. To facilitate a degree of efficiency in the latter stages of the process, however, it appears advisable to have a firm date for intervention rights to conclude.

11. Security and Reliability/Resiliency

Security and reliability of the grid is an important issue that will be impacted by the implementation of the Plan. Increased adoption of DERs causes operational and reliability challenges for the grid. These challenges revolve around four main areas: power quality, control of additional resources, additional load on equipment and managing impacts to baseload generation resources.

Renewable energy sited at customer locations causes localized voltage issues on the grid because the grid was not originally designed with the concept of mid-circuit DERs and two-way energy flow in mind. It has been shown that it is possible for DERs to negatively impact power quality in localized areas, which can cause loss of efficiency and damage the electrical equipment of customers receiving service on those circuits. Grid scale installations of renewable energy have an advantage because they allow the utility the ability to select the best grid locations to integrate renewable additions as well as engineer power quality corrections into the overall installation.

The utility is uniquely positioned to sustainably integrate DERs and energy storage systems in locations that can positively impact grid reliability. However, additional resources and technologies are needed to mitigate challenges to grid reliability. Standards and protocols in this area are still maturing and no utility currently has a fully featured DERMS. While the market and capabilities of these systems are developing and APS is currently working toward implementing its own DERMS, more work needs to be accomplished before a complete system for control and automation is implemented. The utility will need a control system that enables its operators to dispatch these resources at the appropriate times and for appropriate reasons. A simple scheduled algorithm will not suffice as the quantity of DERs increases.

A significant operational issue is the management of APS's baseload generation fleet. Baseload generation facilities are crucial in providing cost-effective power when renewables are not available. Continued expansion of the renewable energy mix is increasing pressure on baseload plants to reduce their output during periods of peak renewable generation. This poses an operational challenge as many of these plants were designed to run long periods of time without shutting down. However, with considerable renewable over-generation already occurring in California, it is becoming increasingly difficult to find a robust market for excess power. When external markets cannot be found, both renewable and baseload generation may be curtailed. Another consequence is that renewable production causes generation ramp rates in the evening to be considerably higher, which in turn, necessitates the construction or procurement of fast-start resources like natural gas-powered combustion turbines.

Grid modernization efforts must continue in order to ensure grid reliability and resiliency.

Grid modernization efforts must continue in Arizona in order to ensure grid reliability and resiliency. There are still a considerable number of distribution circuits where distribution grid operators do not have real-time visualization of current field conditions and the ability to remotely operate devices. These gaps in both situational awareness and the capability to quickly respond must be filled by incorporating devices such as communicating fault indicators, remote controlled switches and two-way communicating voltage controls. Such devices are especially critical in today's environment of rapidly changing grid conditions (as exemplified by reverse power flows) brought about by the increased adoption of DERs. In order to continue to ensure high reliability, investments must be made in advanced grid devices that allow operators to rapidly understand changing conditions and act on them. The ability to react to events – even if only a deviation in voltage – must be efficient and centered on the operators as the first line of recovery for a quicker response. In addition, system improvements must continue to be made in the area of data analytics and automation in order to provide restorative capabilities where automated systems are able to regulate power quality and partially restore customers even before field crews are sent to repair physical damage.

Increasing the number and locations of distributed resources increases the security risk to the grid; more endpoints increase opportunities for a physical or cyber security breach. Utility owned and controlled devices typically present fewer security risks than third-party or customer-sited DERs. This is because utility cybersecurity protections are constructed using a defense-in-depth approach that is regularly reviewed and tested in order to ensure the highest level of security. Additionally, having these resources located at utility facilities specifically built to protect such assets greatly reduces their physical vulnerability. Utility-scale storage and renewable installations would take advantage of already existing monitoring and security controls while also gaining the benefit of currently existing security staff that is trained to protect these assets.

APS RESPONSES TO STAFF NOTICE OF INQUIRY

NOI	QUESTION	RESPONSE
1.a	Please provide a thorough analysis of the prospective cost to ratepayers of the Energy Modernization Plan.	Section 1
1.b	What is the potential impact/consequences to ratepayers?	Section 1
1.c	What is the possibility of stranded investment?	Section 1
1.d	What is the magnitude of stranded investment?	Section 1
1.e	What is the potential for cross-subsidization between regulated public service corporations' functions and non-regulated functions?	Section 1
1.f	What is the positive and/or negative impacts to reliability and resiliency?	Section 11
1.g	What is the amount of additional investment that may be required to comply with or implement the Energy Modernization Plan?	Section 1
1.h	What is the possibility of negative pricing to Arizona ratepayers as a result of the Energy Modernization Plan?	Section 1, Section 7
1.i	What is the magnitude of negative pricing to Arizona ratepayers as a result of the Energy Modernization Plan?	Section 1, Section 7
1.j	How much of the utilities current energy portfolios would be classified as "clean?"	Section 1
1.k	Can utilities project how their energy portfolios will appear by 2050 without the Energy Modernization Plan?	Section 1
1.l	How would future energy planning change for utilities if the Energy Modernization Plan is adopted?	Section 9
1.m	If the Energy Modernization Plan is adopted, would utilities change their plans regarding the useful life of current coal plants?	Section 1
1.n	How does the cost of continued use of coal plants compare to the cost of new natural gas plants or solar projects?	Section 1
1.o	Under the Energy Modernization Plan, do utilities expect they would prematurely close coal plants?	Section 1
1.p	How do utilities expect consumer prices to change with coal plant retirements?	Section 1
1.q	What is the cost per kWh of electricity currently produced at the Navajo Generating Station ("NGS")?	Section 1
1.r	How does that compare to cost per kWh at other coal facilities in Arizona?	Section 1
1.s	What factors are leading to the closing of NGS?	Section 1
1.t	How much does it currently cost to build a utility scale solar project?	Section 1
1.u	How does that compare to the current cost to build a natural gas plant for the same electricity output?	Section 1
1.v	What percentage of each utility's customers currently have residential solar panels?	Section 1
1.w	Please provide the trend over the last five years?	Section 1

APS RESPONSES TO STAFF NOTICE OF INQUIRY

NOI	QUESTION	RESPONSE
1.x	Please project how many new residential solar projects will be completed in the next ten and twenty years?	Section 1
1.y	How much storage is currently being used by the utilities?	Section 4
1.z	How long have those storage projects been in effect?	Section 4
1.aa	What are the capabilities of current batteries in terms of kWh storage?	Table 4.1
1.bb	How much of the peak demand can be expected that storage will be able to mitigate in the next five to ten years?	Section 4
1.cc	How do the utilities expect to invest in storage without the Energy Modernization Plan?	Section 4
1.dd	What energy storage projects are currently being contemplated?	Section 4
1.ee	Is a target of 3,000 MW of energy storage by 2030 an attainable goal?	Section 4
1.ff	Is a mandate related to Arizona's forests a proper function of the Commission's mission to regulate utility rates?	Section 5
1.gg	Is there a constitutional or statutory provision granting authority to the Commission to issue policy regarding Arizona's forests?	Section 5
1.hh	If the health of Arizona forests is a statewide issue, should that issue be debated and discussed at the Arizona Legislature?	Section 5
1.ii	What percentage of Arizona electric customers does the Commission regulate?	Section 1
1.jj	Which utilities provide the balance of the electricity?	Section 1
1.kk	How much biomass energy is currently procured by Arizona utilities?	Section 5
1.ll	Why did utilities decide to enter contracts for biomass energy?	Section 5
1.mm	What is the price per kWh of the current biomass contracts?	Section 5
1.nn	How does that price compare with energy produced from conventional sources?	Section 5
1.oo	Is biomass energy currently procured by any other plant besides Novo BioPower in Snowflake, Arizona?	Section 5
1.pp	Are there any other options for procuring power from biomass in Arizona?	Section 1
1.qq	When do the current power purchase contracts expire?	Section 5
1.rr	Do the utilities expect to renew those contracts? Why or why not?	Section 5
1.ss	Without any action from the Commission, would Arizona utilities continue to procure biomass energy?	Section 5
1.tt	Please explain how utilities currently meet peak demand?	Section 1
1.uu	What is the cost of meeting peak demand for each generating source?	Section 1
1.vv	What is the current feasibility of using dispatchable clean energy during peak demand?	Section 6
1.ww	Are there clean energy projects already contemplated for use during peak demand?	Section 4
1. xx	Is it a proper function of the Commission to require ratepayers to pay for electric vehicle infrastructure?	Section 8
1.yy	What is the relationship between electric vehicle infrastructure and a utility's costs of providing electricity?	Section 8

NOI	QUESTION	RESPONSE
1.zz	If electric vehicle infrastructure would benefit all Arizonans, should the issue be debated and discussed at the Arizona legislature?	Section 8
1.aaa	What percentage of Arizonans currently use fully electric cars?	Section 8
1.bbb	How do Arizonans currently charge their electric car?	Section 8
1.ccc	If Arizonans with electric cars desire charging stations around Phoenix, would the market provide that service?	Section 8
1.ddd	Do Arizona utilities have any plans to be involved with electric car stations?	Section 8
1.eee	If Arizona utilities built electric vehicle infrastructure, would the investments be included in rate base?	Section 8
1.fff	Is it just, fair and reasonable to charge ratepayers for infrastructure that is only used by a certain population of Arizonans?	Section 8
1.ggg	Should a utility customer have exclusive rights to an electric charging station built by that utility?	Section 8
1.hhh	How will the customer be charged, at what rates, and who sets those rates?	Section 8
2.a	Please describe the entities which would be required to participate in the state's energy policy.	Section 2
2.b	Should the Energy Modernization Plan encompass entities not regulated by the Commission such as municipal corporations or quasi-federal entities?	Section 2
2.c	Would legislation be necessary to include such entities as participants in the Energy Modernization Plan?	Section 2
2.d	Should the Energy Modernization Plan apply to all utilities regardless of size or characteristics, or should certain utilities, for example small companies and/or cooperatives, be treated differently?	Section 2
2.e	Please comment on any energy policy in Arizona you deem to be outdated, explain why, and identify proposed improvements to these policies.	Section 2, Section 7
2.f	Please explain the role of traditional regulated energy providers changing in the future as a result of market and technological changes.	Section 2
2.g	Please comment regarding the Energy Modernization Plan's flexibility of allowing 20% of the energy mix to come from resources other than the clean resources described in the Energy Modernization Plan.	Section 2
2.h	Please address anticipated costs of implementation of the CREST standard, including implications for stranded costs, and ratepayer impacts.	Section 1
2.i	What level of existing non-clean resources would have to be retired or sold to merchant companies? How rapidly should retirement occur?	Section 2
2.j	Please discuss the role of merchant generation (clean and non-clean) with respect to the Energy Modernization Plan.	Section 2
2.k	Please comment regarding the appropriateness of the 20% limit on "non-clean" resources.	Section 2
2.l	Is this enough to ensure reliability of the bulk electric transmission system and local distribution systems?	Section 11

NOI	QUESTION	RESPONSE
2.m	Who would benefit, and in what manner, from the Energy Modernization Plan? Please include a consideration of costs associated with the benefits of the Energy Modernization Plan. Should the costs be borne by the beneficiaries?	Section 1
2.n	What role should natural gas, both a fuel for power generation and for the provision of service to end users, play in the Energy Modernization Plan?	Section 1
2.o	Will the flexibility of natural gas-fired generation continue to play an important role in Arizona's energy future?	Section 1
2.p	Given Arizona's expected reliance on natural gas generation in the coming decades, discuss the importance of continued efforts to develop market area natural gas storage and other tools to provide more flexible and reliable natural gas delivery in Arizona.	Section 4
2.q	Should Arizona natural gas and/or propane local distribution companies be included in the Energy Modernization Plan? If so, in what area(s)?	Section 2
2.r	Does the Energy Modernization Plan raise any concerns regarding the "management interference doctrine"? Can these concerns, if any, be addressed through flexibility in the plan implementation?	Section 2
3.a	Should the existing REST rule targets change and if so how should they change?	Section 3
3.b	What other measures should be incorporated to achieve the target of 80% clean energy resources?	Section 3
3.c	Should the Energy Efficiency ("EE") rules, both gas and electric, be revised, repealed, suspended, or integrated into the Energy Modernization Plan?	Section 2 Section 7 Section 9
3.d	Please provide suggestions regarding maximum allowable contributions from clean resources (i.e. targets for specific resources). For example, should there be a maximum percentage of nuclear or solar that contributes to the 80% target, or should the contributions be flexible?	Appendix A
3.e	Should distributed energy resources ("DER") be factored into the 80% target?	Section 7
3.f	How should plans for customer-owned DER be factored into the 80% target?	Section 7
3.g	Please comment on the efficacy of current REST policies and provide suggestions for any specific improvements.	Section 2
3.h	How can the REST and CREST policies be integrated?	Section 2
3.i	How will CREST address the rapidly changing energy landscape (i.e. changing/ future technologies)?	Section 1, Section 9
3.j	Please comment whether, the renewable requirement in the REST rules could or should be increased, to help achieve the 80% clean resource target by 2050.	Section 2
3.k	With regard to CREST, should there be specific targets by clean energy type (i.e. renewable, biomass, nuclear, etc.)?	Section 3
3.l	Are there any qualitative benefits to CREST that should be considered?	Section 3
3.m	How would CREST affect job growth in Arizona?	Appendix A

APS RESPONSES TO STAFF NOTICE OF INQUIRY

NOI	QUESTION	RESPONSE
3.n	What is the total residential/commercial customer cost with and without CREST?	Section 1
3.o	As a part of CREST, should nuclear power be expanded in Arizona? If so, is it advisable to do so while there is no current long-term solution for storage of high level radioactive waste?	Appendix A
3.p	Please comment on why or why not nuclear energy should be considered a renewable energy source.	Appendix A
3.q	Please comment regarding what would happen over the next 30 years if Arizona does not adopt CREST in terms of: i. Ratepayer costs? ii. Electric Grid Stability and Security? iii. Peak Energy Usage? iv. Arizona Economy? v. Arizona Air Quality? vi. Other?	Section 1, Section 3
3.r	Please comment on the "Renewable Electricity Futures Study" ("Study") completed by the National Renewable Energy Laboratory ("NREL") and others. Specifically, please comment regarding the underlying technology cost assumptions, performance assumptions, the energy model used, the timeliness of assumptions, other data inputs, and the overall methodology.	Section 3
3.s	Please comment regarding the rigor and robustness of the Study.	Section 3
3.t	Should there be ongoing review of the conclusions expressed in the Study? If so, how should they be conducted, and by whom? Is such a review planned by NREL?	Section 3
3.u	Please comment regarding any other analyses, journal articles or reports which support, critique or rebut the conclusions of the Study.	Section 3
3.v	Please comment regarding whether there are any readily available studies, reports, or calculations on reduced water usage associated with a large clean resource goal (50% or greater). If so, please identify them.	Section 3
3.w	Please comment on the likelihood of technological advances impacting the renewal of Palo Verde's licenses beyond 2045.	Section 3, Appendix A
3.x	Please comment on any costs associated with keeping Palo Verde operational beyond 2045.	Section 3, Appendix A
3.y	Please comment on the impact to the 80% dean resource target if Palo Verde generation is included or excluded.	Appendix A
3.z	Please comment on any opportunities and the associated costs to further deploy nuclear resources in the State to help achieve the 80% clean resource goal.	Appendix A
3.aa	Please comment on the Energy Modernization Plan's suggestion of ultimately achieving a goal of 100% from clean energy sources.	Section 3
4.a	Please provide comments regarding the proposed amount of storage by 2030. For example, is a storage target of 3,000 MW too high or too low?	Section 4

NOI	QUESTION	RESPONSE
4.b	Please discuss the costs associated with different forms of storage and the extent to which those costs are expected to decline in the future.	Section 4
4.c	Please describe what would be the most accurate method for estimating costs and net cost benefits for the development of this amount of energy storage, or the amount of energy storage you deem appropriate.	Section 4
4.d	Please describe how the obligation for meeting the storage target would be best allocated among utilities.	Section 2, Section 4
4.e	Please describe the most realistic timeline for achieving such a storage target and whether interim targets should be established. For example, what timeframe is the most reasonable for the majority of the 3,000 MW to come online?	Section 4
4.f	Is there a forecast of declining costs which signal a "tipping point" which would make 3,000 MW achievable before 2030?	Section 4
4.g	Please discuss the technical and operational issues, if any, impacting the efficiency of energy storage?	Section 4
4.h	What are typical energy conversion efficiencies for energy storage technologies? (i.e. Lithium ion batteries, pumped hydro, flywheel, etc.)	Section 4
4.i	Should there be any consideration and/or prioritization of different storage functions (e.g. peak shaving, grid support, etc.) within the 3,000 MW target?	Section 4
4.j	Please comment on and describe any resource configurations, which include storage (i.e. solar PV plus storage), that would be cost competitive with resources currently used to address peak demand (i.e. combustion turbines).	Section 4
5.a	Please provide comments regarding the respective roles and fiscal responsibilities of the Federal and State Land management agencies to address concerns regarding overgrown forests.	Section 5
5.b	How will procurement of 60 MWs of biomass benefit individual ratepayers of regulated utilities (investor owned and/or nonprofits)? Will this require ratepayers to pay more for electric service?	Section 5
5.c	Please provide comments regarding the length of time and expense of environmental processes required by state, local, and federal agencies for the siting and permitting of biomass facilities and any necessary transmission lines and roadways.	Section 5
5.d	What is the environmental/habitat impact of removing biomass from Arizona forests?	Section 5
5.e	What is the environmental/habitat impact of generating electricity by biomass?	Section 5
5.f	Please provide comments and data regarding the estimated cost to ratepayers if the 60 MW goal is mandated for regulated utilities.	Section 5
5.g	Please provide comments regarding whether entities not regulated by the Commission should be subject to a biomass goal as it aims to resolve a statewide problem. If so, what is the best method to ensure these entities contribute to a biomass goal?	Section 2, Section 5
5.h	Please comment on the Energy Modernization Plan goal to generate a total of 60 MWs of electricity from biomass.	Section 5

NOI	QUESTION	RESPONSE
5.i	How could this goal be implemented and apportioned among utilities? Please describe the cost of permitting and construction of adequate generation sources and attendant infrastructure to produce 60 MWs of electricity.	Section 2, Section 5, Section 9
5.j	Please comment on transmission costs to deliver biomass produced energy via non- owned transmission lines.	Section 5
5.k	Please comment regarding typical permitting and construction timelines for the construction of biomass facilities and attendant infrastructure such as substations, switchyards, transformers, transmission lines and roadways?	Section 5
5.l	Please comment regarding the current data and research regarding the costs of bioenergy and the conclusion that "the average residential customer's bill will increase by $1.54 for 57 MW of bioenergy statewide, and $2.57 for 87 MW of bioenergy."	Section 5
5.m	Please comment regarding the benefits of forest thinning and how these benefits would factor into utility ratemaking.	Section 5
6.a	Please comment regarding how to ensure dispatchability of clean energy resources, and include a discussion of technologies and costs.	Section 6
6.b	Please comment regarding the costs and impacts of energy storage to reduce demand during peak hours.	Section 6
6.c	Please comment regarding the measurement of improvement of air quality by reducing the need for rapid cycling from gas turbines.	Section 6
6.d	Please comment regarding how the addition of dispatchable clean energy could provide room for baseload power to operate efficiently.	Section 11
6.e	Please comment on the CPT proposed in the Energy Modernization Plan.	Section 6
7.a	Please provide detailed comments regarding appropriate EE initiatives, including percentages of EE and/or demand-side management ("DSM") reduction costs together with a proposed timeline (which includes milestones), and any recommended EE rule changes.	Section 7
7.b	Please comment regarding how EE should be addressed in any resource planning process.	Section 2, Section 7, Section 9
8.a	Should the Commission consider these infrastructure plans as part of its Integrated Resource process?	Section 2, Section 8, Section 9
8.b	What impacts, if any, would Commission approval of utility-owned EV infrastructure plans have on future "prudency" determinations in rate cases?	Section 8
8.c	Please provide comments regarding estimates of future deployment of EVs nationally and in Arizona.	Section 8
8.d	Please provide information on the EV programs in other states.	Section 8

NOI	QUESTION	RESPONSE
8.e	Please provide comments regarding the costs of implementing EV infrastructure, and a proposed means to recover those costs, including potential tax incentives, or utility incentives for customers using EV infrastructure.	Section 8
8.f	Please provide comments regarding metrics and a methodology to measure potential impacts to air quality (including reductions of criteria pollutants) from the potential widespread adoption of electric vehicles.	Section 8
8.g	Please provide comments regarding how to plan EV infrastructure on major highways and interstates, and what collaboration with other agencies would be necessary or advisable.	Section 8
8.h	Please identify any highway funds or other federal monies and grants which may be available to plan and construct such facilities.	Section 8
8.i	Please provide information regarding other utilities in the country who may have undertaken similar efforts to develop EV infrastructure.	Section 8
8.j	When considering development of EV infrastructure, which cost-effectiveness test, or tests, should be utilized to determine the appropriateness of such infrastructure investments?	Section 8
8.k	In keeping with the intent of the Electric Vehicles section of the Energy Modernization Plan, should the use of natural gas fueled vehicles be encouraged?	Section 8
8.l	Should the use of vehicles fueled with Renewable Natural Gas ("RNG") be encouraged? If so, should an incentive program like California's Low Carbon Fuel Standard be encouraged by the Commission?	Section 8
8.m	Please comment on the Arizona Department of Environmental Quality ("ADEQ") estimate that the cost to Arizona for developing and implementing a more stringent air quality plan to reduce emissions would range from $76 million to $380 million. How would these costs be paid, and by whom?	Section 8
8.n	What economic impacts would the adoption of an EV infrastructure plan have on Arizona's economy?	Section 8
9.a	Should the IRP process be modified? If so, please explain how it should be modified.	Section 2, Section 9
9.b	The Commission conducts a Biennial Transmission Assessment ("BTA") as required by ARS 40-360.02 (G). The purpose of the BTA is to examine the adequacy of existing and planned transmission facilities to meet Arizona's energy needs in a reliable manner. 1. How does the Energy Modernization Plan impact the BTA? 2. Should the IRP process and BTA be evaluated jointly?	Section 9
9.c	The current IRP process applies only to specific regulated utilities. How does that fact impact the Energy Modernization Plan?	Section 2, Section 9
9.d	Please comment regarding the current IRP process, and how it should be modified to effectuate the Energy Modernization Plan.	Section 9

APS RESPONSES TO STAFF NOTICE OF INQUIRY

NOI	QUESTION	RESPONSE
9.e	Please comment regarding the 5-year action plans of the utilities and whether the plans should include greater Commission involvement? (For example, explicit approval and or denial of the plans, direction on procuring specific resources to achieve the goals of the Energy Modernization Plan, etc.)	Section 9
9.f	Please comment regarding the 5-year action plans of the utilities and whether it would be beneficial to have more stakeholder engagement in the development of the plans.	Section 9
10.a	Please comment on whether consolidating open dockets would aid in efficiently analyzing proposed rule changes.	Section 10
10.b	Should the dockets listed below be part of such consolidation? i. REST Rule Revisions (Docket No. E-00000R-16-0084) ii. EE Rule Revisions (Docket No. E-00000Q-16-0289) iii. Role of Forest Bioenergy in Arizona (Docket No. E-00000Q -17-0138) iv. Future of Navajo Generating Station (Docket No. E-00000C-17-0039) v. Evaluating Arizona's Current and Future Baseload Security (Docket No. E- 00000Q-17-0293) vi. Innovations and Technological Developments in Generation and Delivery of Energy (Docket No. E-00000J-13-0375)	Section 10
10.c	Are there other dockets that should be included in this list?	Section 10
10.d	Should the implementation of the Energy Modernization Plan be accomplished in a single or multiple rulemaking docket(s)?	Section 10
10.e	What Parties (regulated and non-regulated entities) should participate in the docket?	Section 10
10.f	What other process issues are raised and how can those issues best be addressed?	Section 10
11.a	Discuss any operational and reliability issues associated with implementation of the Energy Modernization Plan.	Section 11, Appendix A
11.b	Are there measures that should be taken to increase overall grid reliability and resiliency in Arizona?	Section 11, Appendix A
11.c	Discuss any security issues that may arise as a result of the Energy Modernization Plan. What can be done to address these issues?	Section 11

Arizona Public Service

Palo Verde Generating Station

April 23, 2018

Appendix A

The Arizona Public Service (APS) vision, which emanates from its values, is to create a sustainable energy future for Arizona. The ongoing success of Palo Verde Generating Station (Palo Verde) is critical to achieving this vision. As the largest power producer in the nation with an economic impact of more than $2 billion annually, Palo Verde is a critical asset to Arizona and the entire Southwest. The station's three units generate enough electricity to meet the needs of more than four million people in Arizona, California, New Mexico, and Texas. Palo Verde was recently described as "the crown jewel of the energy infrastructure in the southwest."[1] The following is an overview of Palo Verde and a description of the attributes that address many of the principles of a clean energy future for Arizona.

Palo Verde is a nuclear steam, electric generating station on a 4,286-acre site approximately 50 miles west of Phoenix. The facility consists of three separate, standardized Combustion Engineering-designed System 80 generating units (CE System 80) and a variety of common support facilities with a total net design electrical rating of 4,003 MW.

The Palo Verde Unit 1 operating license was approved by the Nuclear Regulatory Commission (NRC) in 1984, and the unit entered service in 1986. The Unit 2 operating license was approved by the NRC in 1985, and the unit entered service in 1986. The Unit 3 operating license was approved by the NRC in 1987, and the unit entered service in 1988. In the last decade, each of the units increased their design electrical ratings as a result of steam generator and low-pressure turbine replacements. Unit 1 was increased by 68 MW (from 1,265 MW to 1,333 MW); Unit 2 was increased by 71 MW (from 1,265 MW to 1,336 MW); and Unit 3 was increased by 65 MW (from 1,269 MW to 1,334 MW). Palo Verde is interconnected to the bulk electric system through a switchyard that operates at 525 kV. The interconnected switchyard is co-owned by APS and is operated by the Salt River Project (SRP) Agricultural Improvement and Power District.

Palo Verde is the largest nuclear power station in the U.S. and consistently produces the most power of any power production facility in the country. Furthermore, it is the first and only power plant in the country — of any fuel source — to produce more than 31 million MWh in one year. In 2017 Palo Verde achieved its 26th consecutive year as the nation's largest power producer of any fuel source - a trend that includes 32.2 million MWhs in 2016 and 32.3 million MWhs in 2017. Using the proposed definition of clean energy,[2] all of the energy that has ever been produced, and that will ever be produced, is clean energy.

Ownership Structure

Palo Verde is co-owned by seven southwestern utilities and is operated by APS. The seven Palo Verde co-owners are APS, SRP, Southern California Edison Company, El Paso Electric Company, Public Service Company of New Mexico, Southern California Public Power Authority, and City of Los Angeles Department of Water and Power. Pursuant to a contract between and among the seven co-owners, which is referred to as the Arizona Nuclear Power Project Participation Agreement (Participation Agreement), APS is the NRC operating license holder and the operating agent of Palo Verde. In this regard, APS manages the employees and contractors working at Palo Verde and makes decisions with regard to its safe and reliable operation, such as scheduling maintenance and refueling outages, shutting down a unit for a refueling outage or a short-notice outage when an operating issue arises, and restarting a unit after an outage.

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1 Governor Ducey's Address to the Nuclear Energy Assembly, Scottsdale, Arizona, May 2017.

2 Letter and Proposed Energy Modernization Plan from Commissioner Andy Tobin, Docket No. E-00000Q-16-0289, dated January 30, 2018, at Section II, p.3 (hereinafter, "Energy Modernization Plan").

APS confers with and receives approval from the co-owners on all significant governance issues, including, among other things, capital and operations & maintenance budgets, authorized manning, and planned refueling and maintenance outages. This conferral process is necessitated by a term in the Participation Agreement that decisions of this nature be made with unanimous approval of all seven co-owners.

Reliability

Nuclear power is a reliable, carbon-free source of electricity. With a long history of high capacity factors, Palo Verde closed out 2017 with a 93.8% capacity factor. Nuclear power is the only carbon-free energy source that has fuel assurance, which is defined as having more than 72 hours of fuel available during operation with on-site fuel inventory. This provides system reliability that is independent of external delivery infrastructure, which is vital in an emergency scenario.

Excellence in Safety

Palo Verde was the 35th site in Arizona to be designated with STAR status in the Arizona Department of Safety and Health's Voluntary Protection Program. This program recognizes employers and workers in the private industry and federal agencies who have implemented effective safety and health management systems while maintaining injury and illness rates below national Bureau of Labor Statistics averages for their respective industries.

Economic Impact

Based on an independent economic impact analysis completed in 2017, Palo Verde created an economic impact in the state of Arizona of more than $2.1 billion in 2016 and will create an impact of $10.6 billion in Arizona from 2017 through 2021.[3] In 2016, Palo Verde directly provided about 2,550 "recession-resistant" jobs for employees and contractors. It will directly and indirectly support about 8,000 jobs and $547 million in average annual payroll through 2021. This benefit does not include the economic development advantages of providing reasonable and predictable priced power to the southwest region. To highlight the impact that nuclear plants can have to the local price of electricity, a study of California shows that when the San Onofre Nuclear Generating Station was closed down, the intermediate term wholesale price of electricity went from $36/MWh in 2011 to $42/MWh (normalized for fluctuations in gas prices) in 2012. In 2017, when Palo Verde had an unplanned shutdown, the average price of electricity at the Palo Verde Hub increased from $31.27/MWh to $58-$123/MWh.

Palo Verde also generates a substantial amount of direct property tax revenues to Maricopa County, the community college district, and local school districts. These revenue impacts are in addition to the $2.1 billion economic impact described above. APS is the largest taxpayer in the county, primarily due to taxes associated with Palo Verde. Annual property tax revenues from Palo Verde were approximately $55 million in 2016. In addition, Palo Verde also paid Arizona and Maricopa County sales taxes on some of its purchases, estimated at $7 million in 2016. Since utilities outside of Arizona own 53.4% of Palo Verde, most of the burden for paying for Palo Verde is born by customers outside of the state. Thus, the true cost to Arizona is reduced, providing greater benefit to the citizens of Arizona than to the other states.

[3] Applied Economics, Economic Impacts of Palo Verde Generating Station on Arizona, July 2017.

Clean Air Energy

Lifecycle Emissions

The term gCO2eq/kWh is a unit that describes emissions intensity in grams of carbon dioxide equivalency per kilowatt-hour. The term CO2eq allows other greenhouse gas emissions (*e.g.* methane) to be expressed in terms of CO2 based on their relative global warming potential. The Intergovernmental Panel on Climate Change's Fifth Assessment Report outlines the lifecycle emissions of select electricity supply technologies. While the operating emissions for nuclear, concentrated solar power, solar photovoltaic PV (for both distributed and utility scale), and wind onshore are listed as 0 gCO2eq/kWh, they diverge when accounting for the full lifecycle, which includes items such as infrastructure & supply chain emissions.

In order of smallest lifecycle emissions, in terms of gCO2eq/kWh, the median values are 11 for wind onshore, 12 for nuclear, 27 for concentrated solar power, 41 for solar PV – rooftop, and 48 for solar PV – utility. In a separate study performed by the National Renewables Energy Laboratory, similar conclusions were made, (*i.e.* nuclear power life cycle emissions are on par with solar PV, concentrated solar power, and onshore wind). With respect to Palo Verde, if the plant is operated through the end of the NRC operating licenses by the mid 2040s, the per kWh carbon emissions will be lower since they occur outside of the construction phase, and they will continue to drop the longer the plant operates.

Carbon Dioxide Emissions

The 99 nuclear power reactors in the U.S. provide approximately 20% of America's electricity yet account for nearly 60% of the country's clean energy generation. According to NASA, worldwide estimates covering the years 1971 to 2009 show that the use of nuclear power prevented an average of 64 gigatonnes of CO2 equivalent net greenhouse-gas emissions.[4]

Prudence with carbon dioxide emissions is invariably tied to a changing climate and the resulting effects of increased temperatures. Extreme weather events linked to climate change in the U.S. have cost $1.1 trillion since 1980. Furthermore, extreme temperatures in the future will affect human health, the probability of disasters, water quality, infrastructure and agriculture. These risks are being tracked and are resulting in real business impacts. A Carnegie Institute paper calculated that the world would need to add about a nuclear power plant's worth of clean-energy capacity every day between 2000 and 2050 to avoid catastrophic climate change. To avoid a 2°C warming of the planet, the world needs to cut greenhouse-gas emissions by 70% by midcentury. Carbon pollution, however, is rising. The Carnegie paper concluded that, on the high end, the world needs to construct the equivalent of 30,000 nuclear plants or install 120 billion 250-watt solar panels. The most cost-effective approach moving forward is to create the policy framework to protect the existing nuclear power fleet, encourage advanced nuclear reactor designs, and continue to install other carbon-free generating sources such as batteries, solar and wind technology in a comprehensive fashion to avoid issues such as duck curve saturation, transmission and distribution constraints and reliability issues.

In 2017, Palo Verde produced 32.3 million MWhs that supplied power to Arizona, as well as Texas, California and New Mexico. This is the largest carbon-free, clean energy resource in the country. Localized to Arizona, Palo Verde generates more than 70% of APS's clean air energy. The significance of Palo Verde's carbon dioxide offset can be better comprehended with the following comparisons:

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[4] https://www.giss.nasa.gov/research/briefs/kharecha_02/

- The Palo Verde carbon dioxide offset is comparable to the carbon dioxide equivalent emissions from all of the personal vehicles registered in the state of Arizona.
- The Palo Verde carbon dioxide offset is comparable to the amount of carbon dioxide sequester by the entire forest land in California, which covers a third of the state.

Clean Air Act Pollution Emissions

Palo Verde is operated air pollutant free with the only emissions from nuclear power plant cooling towers being hot water. Solar, hydro, wind and geothermal electricity sources are also emissions-free, but in Arizona nuclear supplies more electricity than all of them combined. Nuclear energy also produces more electricity on less land than any other clean-air source.

Innovation in the Use of Effluent Water

One aspect of Palo Verde that distinguishes it from any other nuclear power plant in the world is that it is not located on or near a large body of water. Therefore, it must obtain water from other sources and must discharge any waste water to a system that will not adversely impact surface or underground water supplies. This unique aspect of Palo Verde is a necessary cost of doing business that is not incurred at any other nuclear power plant in the world. Palo Verde purchases its cooling water from two waste water treatment plants (WWTP) located in the greater-Phoenix area: (1) the 91st Avenue WWTP, operated by the City of Phoenix on behalf of the Sub Regional Operating Group cities of Glendale, Mesa, Phoenix, Scottsdale, and Tempe; and (2) the City of Tolleson WWTP. Effluent from the 91st Avenue and Tolleson WWTPs is conveyed 36 miles to Palo Verde. Once received at Palo Verde, the effluent is treated at the Palo Verde Water Reclamation Facility to remove ammonia and minerals that would otherwise damage or cause scaling on vital plant cooling components. After being treated, the water is stored in either one of Palo Verde's on-site 45-acre or 85-acre reservoirs. When cooling water is needed, it is pumped to the cooling towers where it is cycled more than 20 times before a small amount (less than 5%) is blown down and discharged to one of the three evaporation ponds. The remaining 95% of the cooling water is evaporated to the atmosphere.

The Water Reclamation Facility operations described above require a separate physical water treatment plant with a staff of approximately 100 people, along with chemicals, materials, and supplies. Additionally, as a zero-liquid discharge plant, Palo Verde must also operate and maintain three very large evaporation ponds — covering 250, 220, and 180 surface acres, respectively, for a total of 650 acres — until all the cooling tower blowdown water evaporates. In all other nuclear plants, the cooling water would simply be discharged into the river, lake, or ocean from which it was withdrawn.

Staffing for the Long Term

Palo Verde is typically staffed with approximately 2,200 full time employees. As the nationwide nuclear industry workforce ages, APS – like the rest of the industry - continues to manage the wave of retirements that are affecting the industry. Since 2007, Palo Verde has replaced approximately 1,600 employees, which is nearly three fourths of its work force. To address this turnover, Palo Verde has a comprehensive hiring strategy and talent acquisition process. For those skilled positions that are challenging to fill, Palo Verde has a robust knowledge transfer and retention process. Certain positions require several years to train and qualify a worker. To facilitate the knowledge transfer that has previously taken place and inevitably will continue to take place, Palo Verde will hire early enough in advance of projected and anticipated retirements so that it maintains its complement of fully qualified workers.

Palo Verde works with local high schools, community colleges, and universities to develop new talent. For example, Palo Verde management has been instrumental in creating the Western Maricopa Education Center (West-MEC) Southwest Campus, an energy-centric campus and program in Buckeye. West-MEC is an Arizona public school district dedicated to providing innovative career and technical education programs that will prepare students for economic independence. Palo Verde also continues to foster its long-term relationship with Estrella Mountain Community College and routinely recruits and hires engineers from Arizona's three public universities for its engineering legacy program.