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IN THE MATTER OF RESOURCE PLANNING AND PROCUREMENT IN 2011 AND 2012.	DOCKET NO. E-00000A-11-0113

COMMENTS OF WESTERN RESOURCE ADVOCATES

Western Resource Advocates (WRA) hereby submits its initial comments on the 2012 Integrated Resource Plan filed by Arizona Public Service Company (APS), dated March 2012. The comments were prepared by David Berry, Stacy Tellinghuisen, and Jeremy Lewis.

WRA appreciates the opportunity to provide comments.

Respectfully submitted this 7th day of September, 2012.

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COMMENTS OF WESTERN RESOURCE ADVOCATES ON ARIZONA PUBLIC SERVICE COMPANY'S 2012 INTEGRATED RESOURCE PLAN DOCKET NO. E-00000A-11-0113

Contents

1. Introduction

This section provides a summary of Arizona Public Service Company's (APS's) resource plan and an overview of Western Resource Advocates' evaluation of APS's plan.

A. Summary of APS's resource plan

APS noted that *"Resource planning is not an absolute prediction regarding the future resource picture. The only certainty the Company has at the time of this filing is that over the course of the Planning Period, conditions will change and impact areas covered in this report. As such, this [plan] should not be viewed as an end in itself but as a marker against which progress can be measured and future plans further refined"* (p. 17). *"Least-cost planning – the historical resource planning approach among many utilities – has given way to a more far-reaching approach, one that encapsulates environmental impact, diversity of resources, a more comprehensive view of technology, a greater reliance on customer-powered programs, and a more profound use of renewable resources"* (p. 24).

APS considered four alternative resource portfolios covering the period 2012 to 2027. Each portfolio assumes the same demand forecast.

1. A base case portfolio in which Four Corners Units 1-3 are retired and Southern California Edison's share of Four Corners Units 4 and 5 is acquired. This portfolio contains nuclear, coal, gas, and clean energy resources (renewable energy and energy efficiency) in roughly equal proportions in 2027. APS characterizes this portfolio of resources as the one that is best for customers (pp. 5 and 144).
2. A Four Corners contingency portfolio in which all of Four Corners is retired and replaced by natural gas resources. This portfolio applies to the case where the transaction with Southern California Edison is not completed. Under this case, APS becomes highly reliant on natural gas generation.
3. An enhanced renewable energy portfolio in which APS obtains about 30% of its retail sales from renewable resources toward the end of the planning horizon. Reliance on gas generation is greatly reduced as compared to the other portfolios.
4. A coal retirement portfolio in which all coal-fired generation is gradually retired and replaced with natural gas generation and renewable resources. This portfolio is heavily dependent on gas generation.

The major differences in resource mixes across the portfolios pertain to the amount of coal, gas and renewable resources. APS assumes that it will meet the energy efficiency standard and meet or exceed the renewable energy standard in all of the resource portfolios, and that the amount of energy obtained from nuclear generation is the same in all portfolios.

APS's demand forecast takes account of the effect of the recession on the demand for electricity but assumes an eventual return to historic growth rates. APS implies (p. 144) that its base case plan is sufficiently flexible to accommodate variations from its load forecast by changing the timing of short lead-time resources as necessary.

APS faces numerous risks over the next 15 years. Among these risks are uncertainties about natural gas prices, whether federal tax incentives for renewable energy will be continued, the costs of energy efficiency resources, and the costs of complying with possible future regulation of carbon dioxide emissions. APS therefore tested a variety of assumptions affecting the cost of each portfolio using sensitivity analyses, including a case where monetized externalities for SO_2, NOx, and particulate matter are included in dispatch costs. These tests show the degree to which costs may change under both adverse and favorable conditions. APS concluded that its base case portfolio would tend to have the lowest cost (present value). APS emphasizes the importance of maintaining a diverse set of resources to manage the variety of risks occurring over the planning horizon.

APS noted that: *"While fossil-fueled generation sources may have been the dominant choice years ago, renewable technology advancements and energy efficiency provide utility planners with cleaner resource choices that mitigate the risk of potential health effects associated with power generation"* (p. 137).

Lastly, APS presents a 3 year action plan which assumes that it will continue to meet renewable energy commitments and will meet the energy efficiency standard. However, because of uncertain load growth and uncertainties about whether planned efficiency and renewable resources will be fully deployed, APS is also developing options for new gas generation as early as 2016.

B. Overview of Western Resource Advocates' comments

These comments present Western Resource Advocates' (WRA's) initial review of Arizona Public Service Company's 2012 Integrated Resource Plan.

In general, resource planning has multiple objectives:

- Reasonable societal costs over the long run as determined by comparing cost estimates for a variety of portfolio options
- Consideration of a wide range of resource options including supply and demand side resources and customer owned resources
- Long run risk management
- Maintenance of a reliable system
- Compatibility of power production and delivery with environmental values
- Incorporation of public input

In Arizona, there are several overarching issues that must be considered by utilities and the Commission in preparing and reviewing electric utility resource plans:

- **Wasted energy**. Consumers waste large amounts of energy, resulting in higher fuel costs and investments in unnecessary generation capacity additions. These costs are paid by all customers to produce electricity that is wasted.
- **Pollution**. The current power supply system emits huge quantities of pollutants into the atmosphere, resulting in adverse health and other environmental impacts.
- **Fuel price risk.** The current power system is vulnerable to fuel price increases and fuel price volatility.
- **Water supply risk.** Conventional steam generation technology is vulnerable to water scarcity in an arid region.
- **Resource flexibility.** Resource flexibility refers to the capability of the electric system to adjust to rapid changes in the supply of and demand for electricity.
- **Reasonable cost.** The reasonableness of costs can be determined by comparing estimated costs of a variety of options, keeping in mind the uncertainties inherent in long term projections.

We reviewed APS's resource plan in light of these issues and conclude that: APS's intent to meet the Commission's energy efficiency standard will significantly reduce wasted energy; coal plant retirements will greatly reduce air pollution; increased reliance on stably priced renewable energy and energy efficiency will hedge against higher fossil fuel costs; use of dry cooling as proposed by APS will help manage the risk of water scarcity; energy storage facilities can improve system flexibility; and pursuing a plan consistent with these findings can be accomplished at a cost that is about the same as the cost of APS's preferred (base case) plan.

Therefore, we **recommend that**:

- The Commission approve APS's 3 year action plan (APS resource plan, pp. 147-154).
- The Commission acknowledge APS's **enhanced renewable energy and coal retirement portfolios** and direct APS to prepare an option for the next resource plan filing that blends the enhanced renewable energy and coal retirement portfolios.
- The Commission employ a workshop process to establish a basis for early adoption of energy storage projects and services.

2. A Path Forward

The Commission should view resource planning as an opportunity to make continued progress toward achieving a lower risk, flexible, reasonably priced, and environmentally sustainable mix of electric energy resources. Figure 1 summarizes Western Resource Advocates' perspective on how Arizona should move forward.

The benefits of taking the steps shown in Figure 1 include the following:

a. Significantly less wasted energy through implementation of the Commission's efficiency standard as proposed by APS.
b. Greatly reduced air emissions (including SO_2, NOx, and CO_2) resulting in a reduction in adverse health and other environmental impacts of power generation.
c. Reduced exposure to fossil fuel price uncertainty through increased use of stably priced renewable energy and energy efficiency and less reliance on natural gas and coal-fired generation.
d. Strengthened hedges against long term water shortage risk through dry cooling, energy efficiency, and low water-use renewable energy.
e. Greater system flexibility through energy storage and more efficient use of the grid.
f. Reasonable costs – the path forward shown in Figure 1 would cost about the same as APS's preferred base case portfolio, given the uncertainties about future costs.

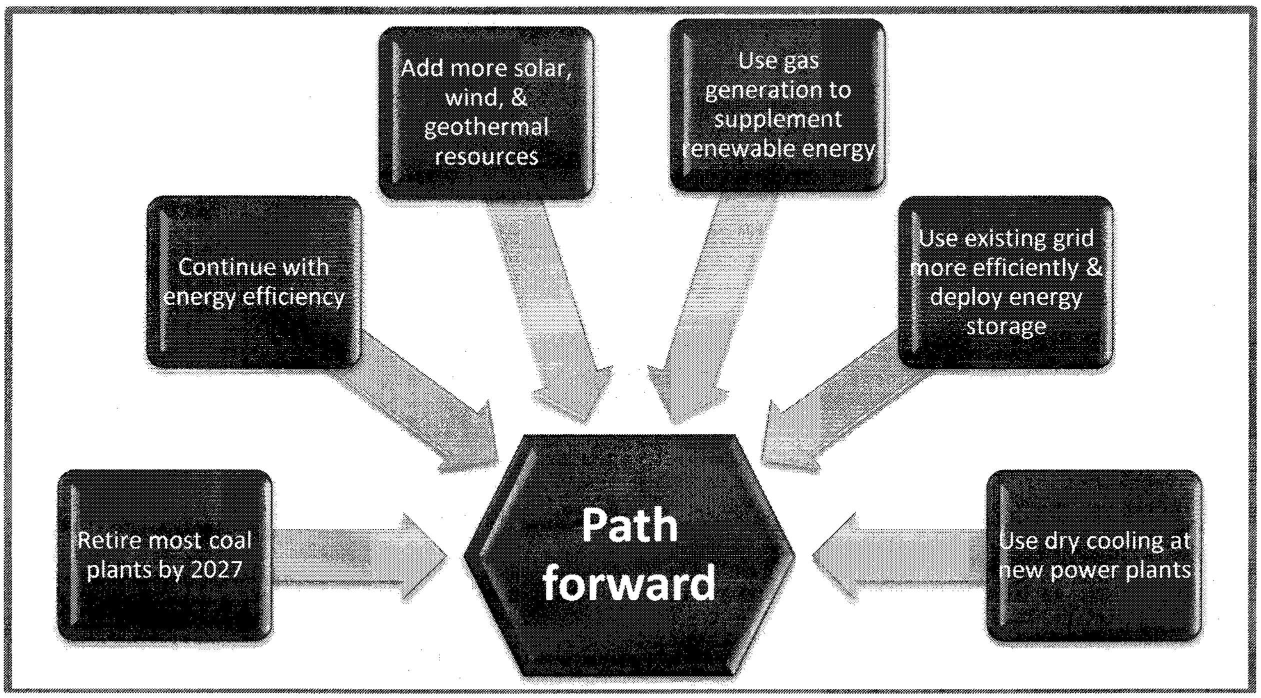

Figure 1

Our proposed path forward reflects what Arizona consumers have said:

- The Morrison Institute's informed perception project report indicates very strong support for renewable energy, for minimizing air pollution, for avoiding outages on hot days, for reducing greenhouse gases, and for keeping rates low, among other factors.[1]
- In a 2007 poll, Public Opinion Strategies found that "A stunning 87% of the electorate prefers to address Arizona's current energy situation by 'increasing energy efficiency and using more clean energy sources like wind and solar power' rather than by

[1] Morrison Institute for Public Policy, Arizona State University. *APS Informed Perception Project Report*, May 2011, p. 21.

'importing more electricity from coal power in other states'" and that "There is strong support for a variety of proposals to increase the use of renewable energy in the state, and an overwhelming majority say they would be willing to pay higher energy prices to increase the use of clean energy."[2]

- In a 2011 poll, Public Opinion Strategies and Fairbank, Maslin, Maullin, Metz & Associates found that "Affordability of energy is very important to Arizonans, but a solid majority says it is not worth greater pollution" and that "Arizona voters view renewable energy sources quite positively, and say it is time to start transitioning away from coal and toward these other energy sources."[3]

3. Energy Efficiency

There are many opportunities to reduce the amount of wasted energy at lower incremental cost than generating more electricity and adding new generation capacity.[4] Moreover, numerous customers want to be more energy efficient as evidenced by the large participation in utility-administered efficiency programs. Table 1 summarizes APS' recent experience with energy efficiency. APS has been able to accomplish significant savings in a cost effective manner as reflected by the large societal net benefit.

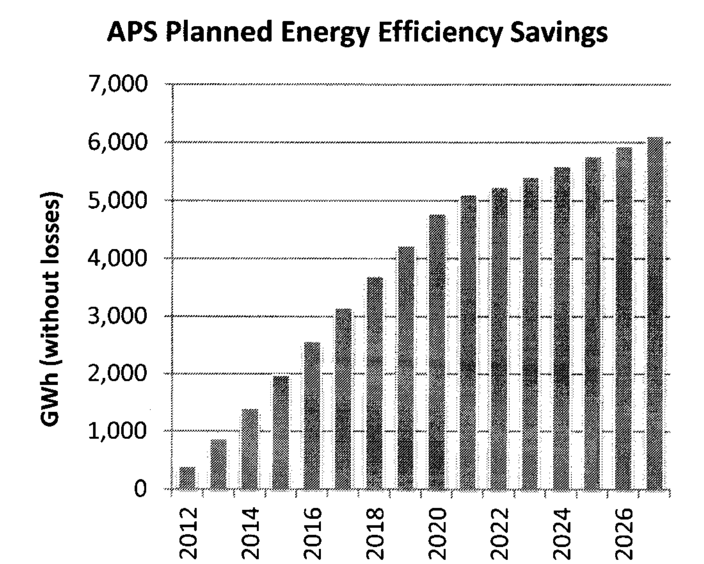

Figure 2

Figure 2 shows APS's planned energy efficiency savings at the meter, excluding savings achieved as a result of efficiency efforts undertaken in prior years. APS indicates that the planned savings will be sufficient to meet the Commission's energy efficiency standard (APS Resource Plan, Table 41, p. 144).[5]

The amount of energy efficiency planned by APS will reduce revenue requirements by about 8.7% of what revenue requirements would have been in the absence of the efficiency

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[2] Public Opinion Strategies. "Arizona: Energy Resources and Public Opinion," 2007. Quotes are from pp. 1 and 2.
[3] Public Opinion Strategies and Fairbank, Maslin, Maullin, Metz & Associates. "Key Findings from a Survey of Arizona Voters Regarding Increasing the Use of Renewable Sources for Electricity Production," February 24, 2011. Quotes are from pp. 3 and 4.
[4] McKinsey Global Energy and Materials, *Unlocking Energy Efficiency in the U.S. Economy*, 2009.
[5] WRA requested that APS show how its planned level of savings meets the energy efficiency standard taking into account provisions in R14-2-2404 that allow utilities to credit certain activities toward the standard beyond those achieved through utility efficiency programs during a given year. However, APS did not provide a complete response.

savings over the period 2012-2027.[6] Figure 3 shows the avoided capacity and energy costs resulting from APS' planned energy efficiency savings under the base case portfolio. The present value of the stream of avoided costs over the period 2012 to 2027 is $2.5 billion using a nominal discount rate of 7.95%.

We support APS's intent to meet the Commission's energy efficiency standard. The standard is reducing the costs of meeting the demand for electric energy services.

Table 1. Summary of APS Efficiency Programs 2009-2011.

Metric	Value
Program cost 2009-2011	$139 million
Annual MWh saved in 2011 due to measures installed 2009-2011	925,625 MWh
Lifetime MWh saved due to measures installed 2009-2011	9,652,868 MWh
Program costs per lifetime MWh saved	$14.40
Capacity savings (MW) due to measures installed 2009-2011	149 MW
Societal net benefits from measures installed 2009-2011	$354 million
Avoided CO_2 emissions over measure lifetimes due to measures installed 2009-2011	3,944,027 metric tons

Sources: APS Demand Side Management Semi-Annual Reports filed with the Arizona Corporation Commission

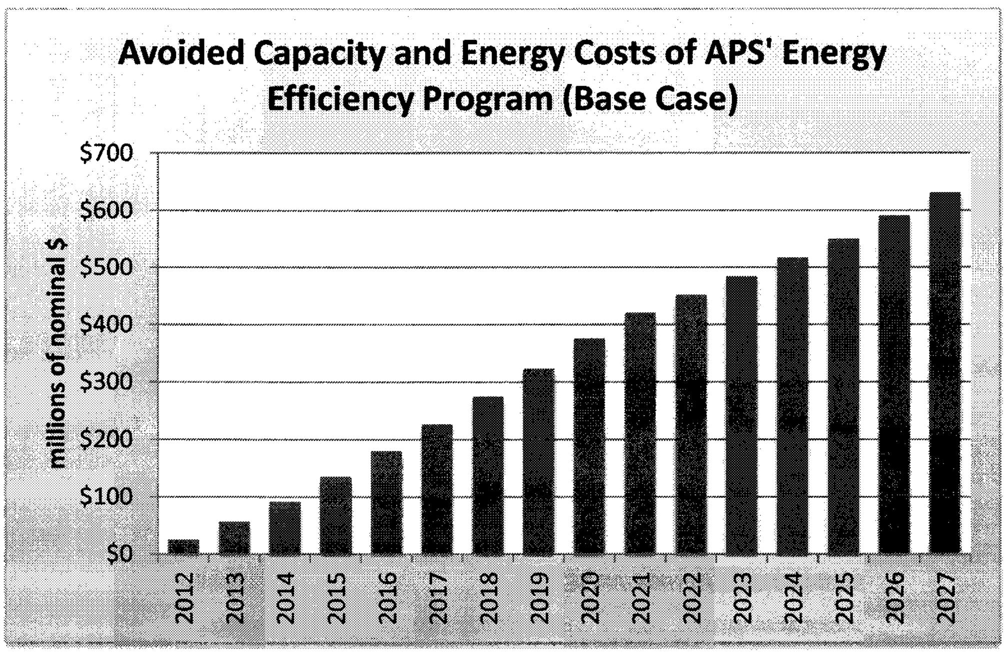

Figure 3

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6 Calculated by WRA using data from APS Resource Plan, Pages ATT-9, *et. seq.* for avoided energy and ATT-77 for avoided capacity including avoided reserve margins, and page 83 and ATT-7 for cost data. Projected natural gas prices from EIA, *Annual Energy Outlook 2012*, Reference Case.

4. Environmental Effects of Generating Electricity with Coal

Burning fossil fuels, especially coal, results in numerous adverse consequences for human health and for the environment. These impacts include the following:

- Health effects due to formation of fine particulate matter from SO_2, NOx, and other compounds in the atmosphere resulting in:[7]
  - Asthma
  - Bronchitis
  - Heart attacks
  - Premature mortality.
- Climate change induced by carbon dioxide and other greenhouse gas emissions.[8]
- Other effects on fish and wildlife, visibility, and human health due to mercury and other air toxics emissions, aerosols, ground level ozone, impingement and entrainment of fish, and from improper coal ash storage.

A. Health impacts

In 2010, coal-fired power plants in Arizona and New Mexico emitted 53,000 tons of SO_2 and 117,000 tons of NOx.[9] Figure 4 shows the sources of these emissions. The biggest emitters of SO_2 in 2010 were the Coronado and Four Corners plants. The biggest emitters of NOx in 2010 were the Four Corners and Navajo plants.

Health impacts of coal-fired power plants can be significant. Figures 5 and 6 show the Clean Air Task Force/Abt Associates estimates of health impacts attributable to fine particulates resulting from emissions at Arizona and New Mexico coal-fired power plants which serve Arizona consumers.[10] Fine particulates are formed in the atmosphere by reactions with SO_2

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[7] C. Arden Pope III and D. Dockery, "Health effects of fine particulate air pollution: lines that connect." *Journal of the Air and Waste Management Association* 56 (2006), 709-742. C. Arden Pope III, M Ezzati, and D. Dockery, "Fine-particulate air pollution and life expectancy in the United States," *The New England Journal of Medicine* 360 (January 22,2009), 376-386. F. Laden, J. Schwartz, F. Spelzer, and D. Dockery, "Reduction in fine particulate air pollution and mortality: extended follow up of the Harvard six cities study." *American Journal of Respiratory and Critical Care Medicine* 173 (2006), 667-672.

[8] See for example: J. Hansen, M. Sato, R. Ruedy, K. Lo, D, Lea, and M. Medina-Elizade, 2006. "Global temperature change." *Proceedings of the National Academy of Sciences* 103(39): 14288-14293. Susan Solomon, et al., "Irreversible Climate Change Due to Carbon Dioxide Emissions," *Proceedings of the National Academy of Sciences* 106 (February 10, 2009), 1704-1709. Richard Seager et al., "Model projections of an imminent transition to a more arid climate in Southwestern North America," *Science* 316 (May 25, 2007), 1181-1184. Gian-Reto Walther, et al., "Ecological responses to recent climate change," *Nature* 416 (March 28, 2002): 389-395. Jonathan Overpeck and Jeremy Weiss, "Projections of future sea level becoming more dire," *Proceedings of the National Academy of Sciences* 106 (December 22, 2009): 21461-21462.

[9] Data are from EPA: http://ampd.epa.gov/ampd/QueryToolie.html.

[10] The health impacts were estimated by Abt Associates for the Clean Air Task Force. Clean Air Task Force, *The Toll from Coal*, Boston, 2010. Abt Associates, *Technical Support Document for the Powerplant Impact Estimator Software Tool*, Cambridge, MA, 2010. Data on individual power plants may be found at:

and NOx. The estimates in the figures should be regarded as approximate as they are based on statistical relationships between concentrations of fine particulates in the atmosphere and health effects, and on modeling of fine particulate formation and dispersion of pollutants.

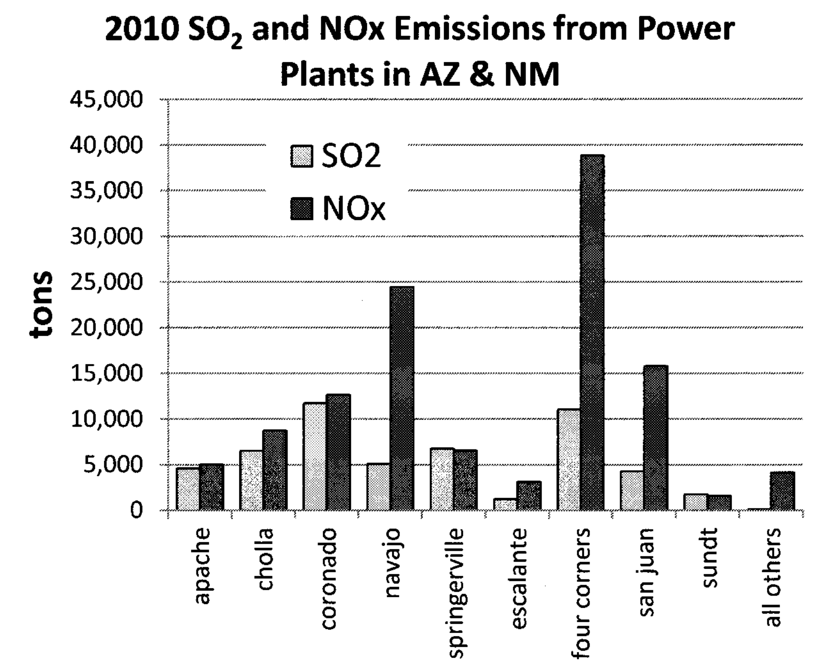

Figure 4

As more emission controls are added to coal-fired power plants and as coal plants are retired, health impacts will diminish. APS's resource plan (pp. 105 *ff.*) indicates that reductions in SO_2 and NOx emissions from its coal-fired resources will occur in the next few years. Retirement of Four Corners Units 1-3 and selective catalytic reduction at Four Corners Units 4 and 5 are expected to reduce SO_2 and NOx emissions. APS also plans a fabric filter installation and scrubber upgrades at Cholla Unit 2 to reduce SO_2 and particulate emissions. The U.S. Environmental Protection Agency (EPA) has proposed that Cholla Units 2-4 be equipped with selective catalytic reduction to reduce emissions of NOx.[11] EPA estimated the annual cost of selective catalytic reduction to be $7.5 million for Cholla 2 and $8.1 million for Cholla 3.[12]

APS also indicates that existing or planned fabric filters at Four Corners and Cholla may be adequate to meet the Mercury and Air Toxics Standard but that brominated activated carbon injection may be necessary at Four Corners Units 4 and 5 and that activated carbon injection would be needed at Cholla.

It is not clear what additional pollution control equipment, if any, the owners would install in the future at the Navajo Generating Station (which has low NOx burners and over-fire air to control NOx emissions, limestone scrubbers, and electrostatic precipitators).

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http://www.catf.us/coal/problems/power_plants/existing/. To our knowledge, this is the only recent study that provides physical health impact estimates by power plant.

[11] 77 *Federal Register*, July 20, 2012, 42834-42871. The compliance date for NOx emissions would be in 5 years.

[12] EPA, *Arizona Regional Haze Technical Support Document*, July 2012, Tables 23 and 26.

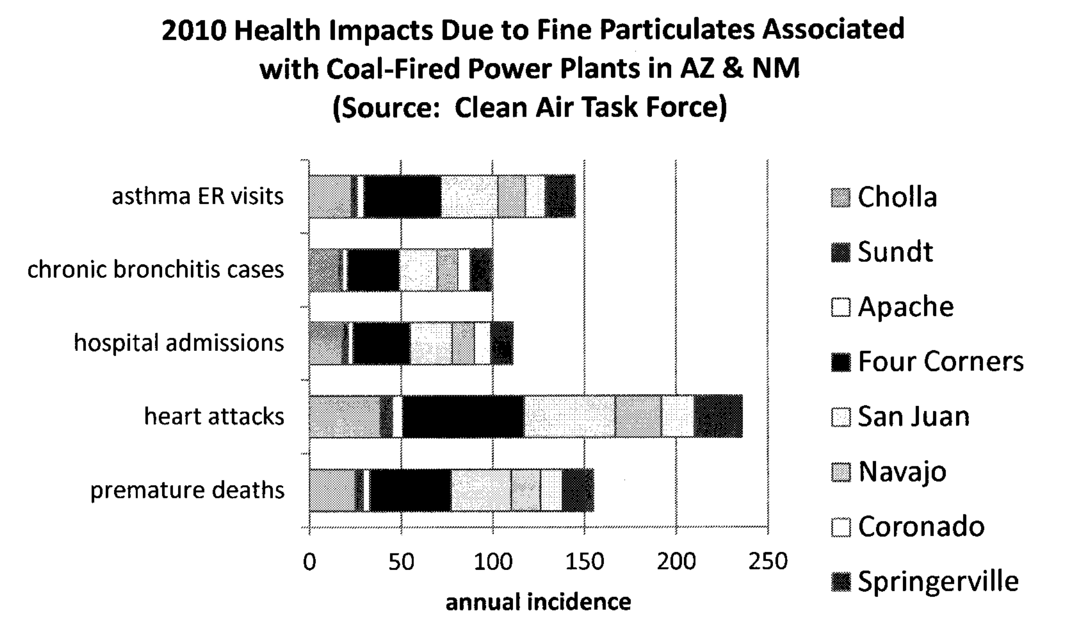

Figure 5

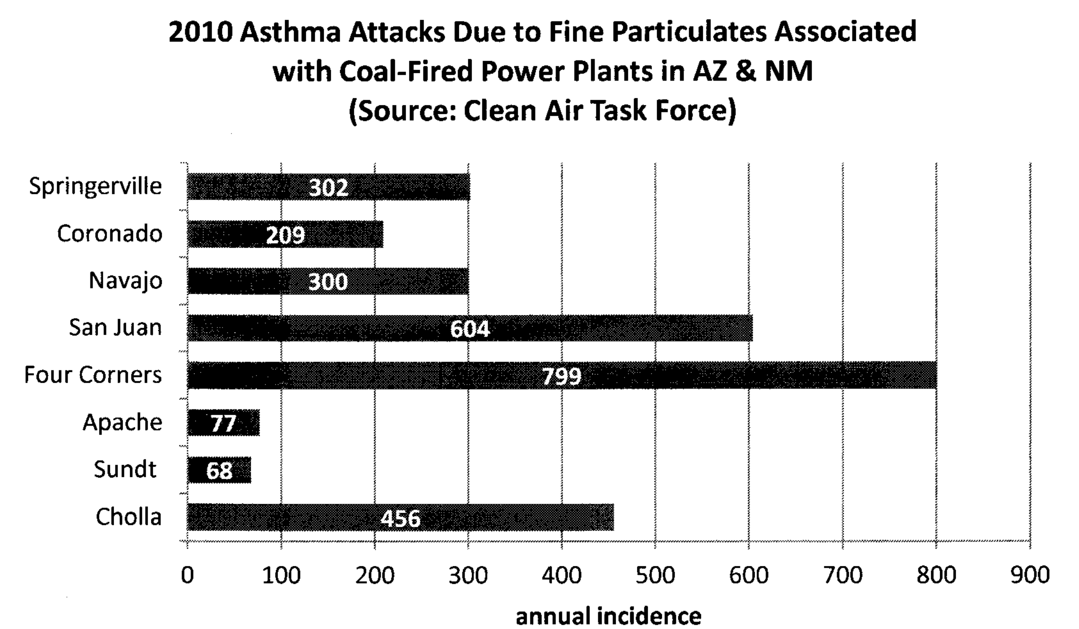

Figure 6

B. Carbon dioxide

Carbon dioxide is a major anthropogenic source of greenhouse gases contributing to climate change. Most of the carbon dioxide emitted by power plants comes from coal-fired plants.

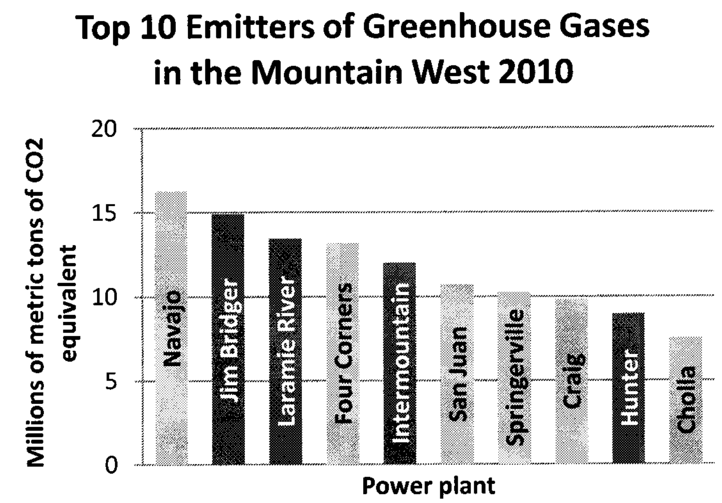

Figure 7

The consequences of climate change for the Southwest include:

- Hotter temperatures[13] (see appendix for data on the temperature trend in Arizona and its effect on electricity use)
- Prolonged drought[14]
- Ecological shifts (such as relocation of species or changes in dates of events like arrival of bird species)[15]

Figure 7 shows the top 10 emitters of CO_2 in the Mountain West region.[16] Six of these plants, shown with a lighter color, serve Arizona consumers. Because of multiple ownership of many of these plants, the total amount of carbon dioxide emitted from a particular plant may be attributable to several utilities.

Of the four portfolios analyzed in APS's resource plan, only the coal retirement portfolio makes a sustained dent in CO_2 emissions (Figure 8). Two of the other portfolios reduce emissions slightly, and the base case increases emissions. These patterns are a consequence of the mix of coal, gas, and renewable energy resources that are briefly discussed in section 5, below.

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[13] Thomas R. Karl, Jerry M. Melillo, and Thomas Peterson, eds., *Global Climate Change Impacts in the United States*, Cambridge University Press, 2009. J. Hansen, M. Sato, and R. Ruedy, "Perception of Climate Change," *Proceedings of the National Academy of Sciences*, Early Edition (August 6, 2012), www.pnas.org/cgi/doi/10.1073/pnas.1205276109. Note that temperature increases are also due to the urban heat island effect: Sally Wittlinger, "The urban heat island: jeopardizing the sustainability of Phoenix," *Policy Points*, vol. 3, no. 3 (July 2011), Arizona State University Morrison Institute for Public Policy.

[14] K. Strezpek, et al., "Characterizing changes in drought risk for the United States for Climate Change," *Environmental Research Letters*, 5 (2010). R. Seager et al., "Model projections of an imminent transition to a more arid climate in Southwestern North America, *Science*, vol. 316 (May 25, 2007): 1181-1184.

[15] Gian-Carlo Walther, et al., "Ecological responses to recent climate change," *Nature*, vol. 416 (March 28, 2002): 389-395.

[16] Data are from EPA: http://ghgdata.epa.gov/ghgp/main.do

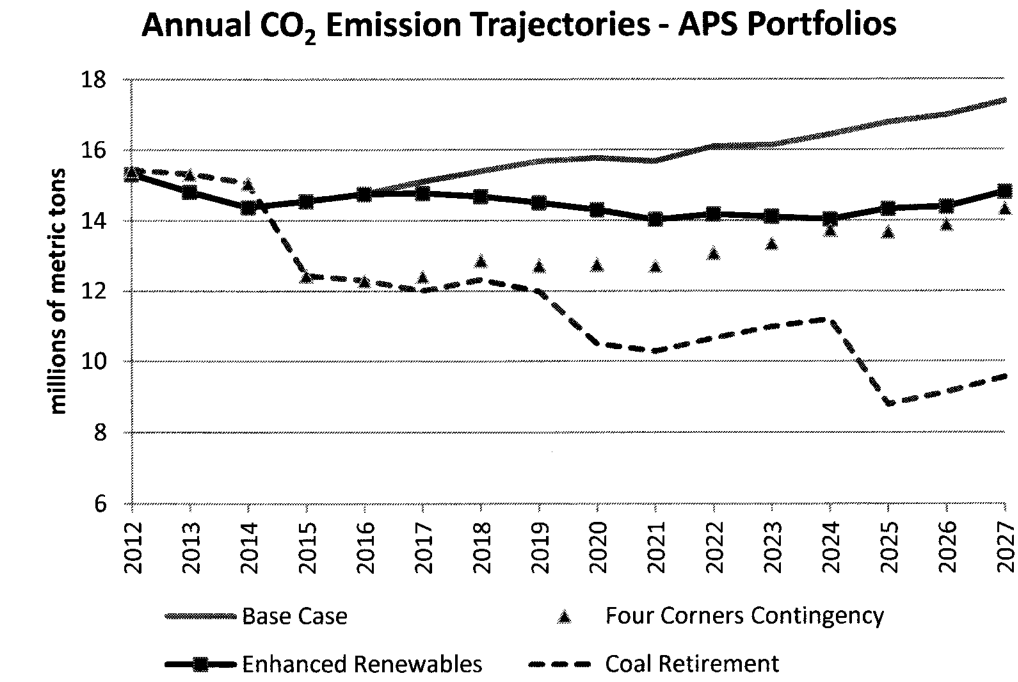

Figure 8

C. Coal ash

Figures 9 and 10 show the amount of coal combustion waste produced by power plants in Arizona and New Mexico in 2010 and the costs and revenues associated with that waste (revenues come from the sale of byproducts to the construction industry and others).[17] There is a lot of coal combustion waste that is expensive to collect and dispose of. Regulation of coal ash is also being considered by the Environmental Protection Agency which may increase collection and disposal costs. Where power plants have joint ownership, Arizona utilities are responsible for only a share of the total coal combustion waste costs.

D. Summary

In sum, coal-fired power production imposes very large health and environmental costs on Arizona and the nation. Resource portfolios that greatly reduce conventional coal generation will reduce air emissions and coal ash, thereby lowering the costs to society of meeting the demand for electric energy services.

[17] Data are from EIA Form 923 for 2010.

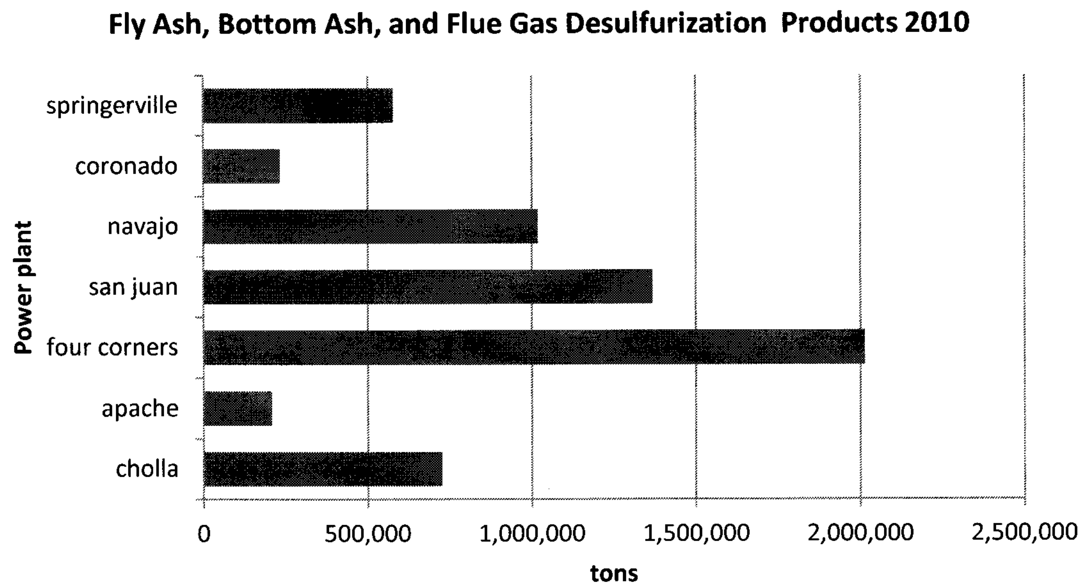

Figure 9

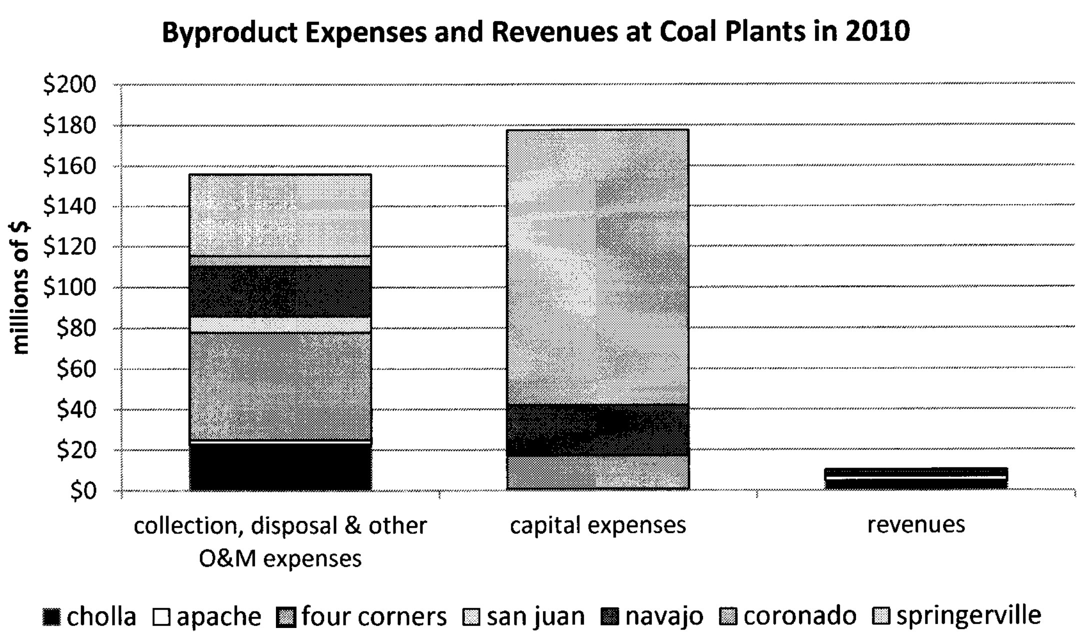

Figure 10

5. Hedging Against Fuel Price Increases

This section addresses the fuel price risk associated with natural gas, coal, and nuclear power generation and how to manage those risks. Figure 11 shows the mix of resource types in 2027 for each of the four portfolios analyzed by APS. Coal, gas, and nuclear resources comprise between 62% and 71% of each portfolio in 2027.

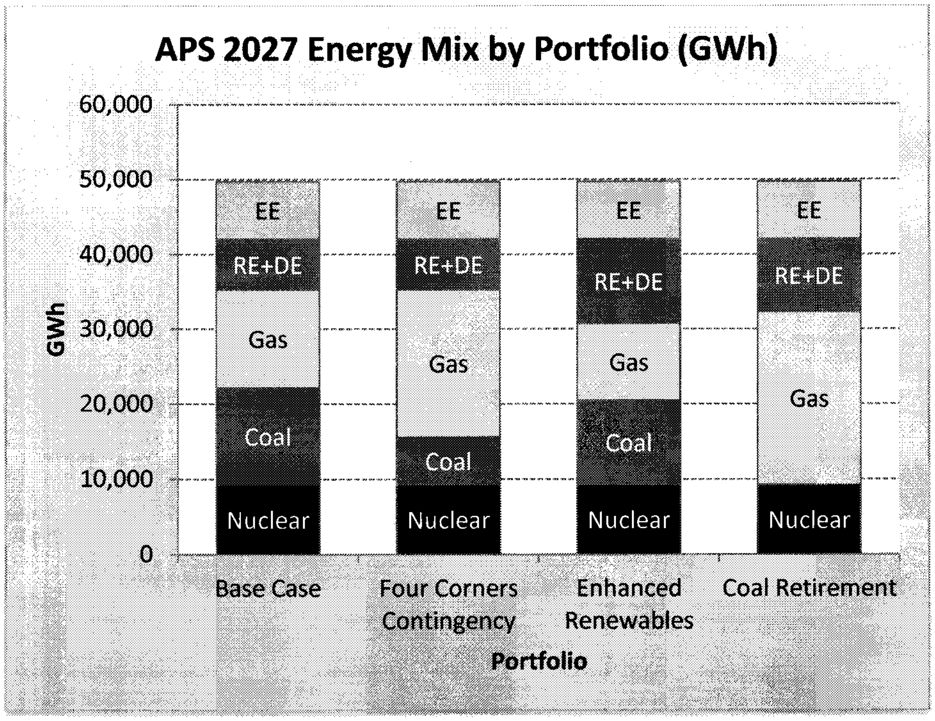

Figure 11

Coal and uranium prices (in constant dollars) have increased in recent years and natural gas prices are quite volatile (Figures 12-14).[18] The potential for future price changes generally introduces a great deal of uncertainty into long range planning. **In contrast, renewable energy and energy efficiency do not, in most cases, incur fuel costs and so provide a physical hedge against high conventional fuel prices and against fuel price volatility.**

APS and other western utilities tend to purchase much of their coal under long term contracts so price volatility may be attenuated. Nonetheless, long term contract prices are often indexed to various inflation factors so coal prices are not flat. Additionally, coal contracts

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[18] Data from Energy Information Administration: *Annual Energy Review 2010*; "Natural Gas Summary," http://www.eia.gov/dnav/ng/ng_sum_lsum_a_epg0_peu_dmcf_a.htm; *Cost and Quality of Fuels for Electric Utility Plants,* various years; *Electric Power Monthly*; and *Uranium Marketing Annual Report*. The gas price graph (Figure 12) includes the EIA *Annual Energy Outlook 2012* forecast of gas prices paid by the electric power sector nationally.

are periodically renewed or replaced, presenting an opportunity for price changes. Further, for plants that have coal delivered over long distances, transportation costs can be a large portion of the price and transportation costs will tend to reflect fuel costs for railroads, capacity additions or upgrades on railroads, and congestion costs on railroads.

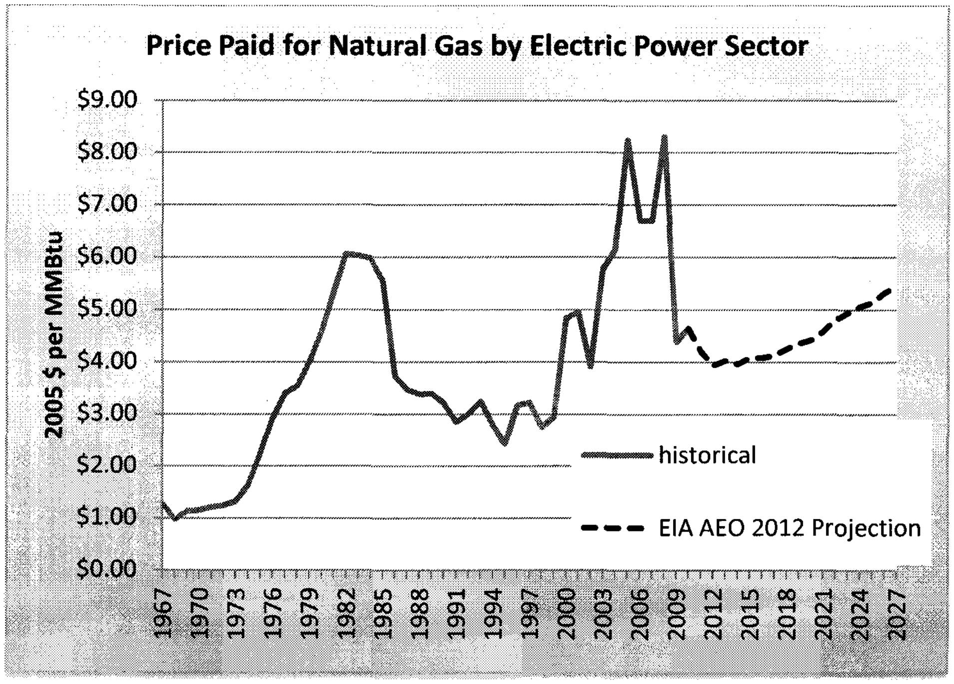

Figure 12

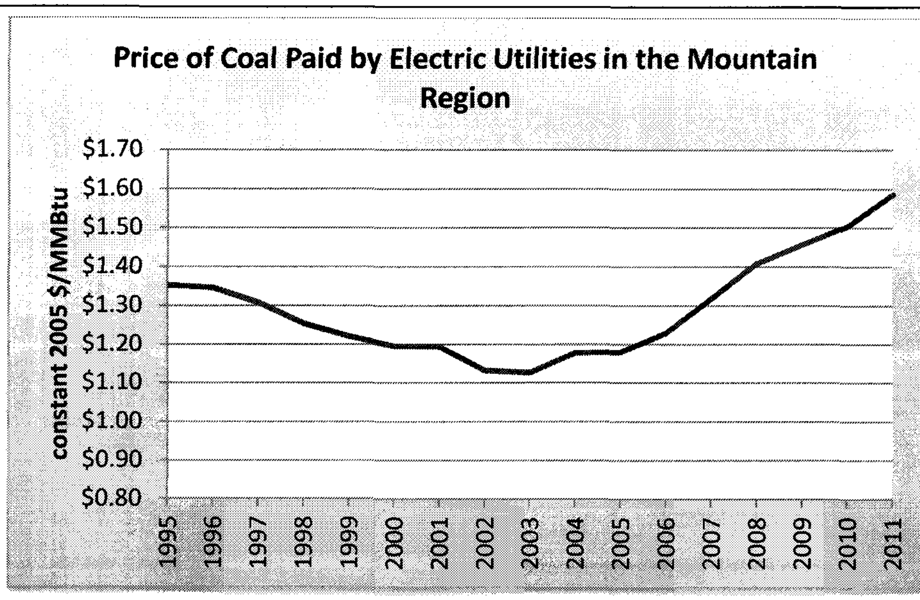

Figure 13

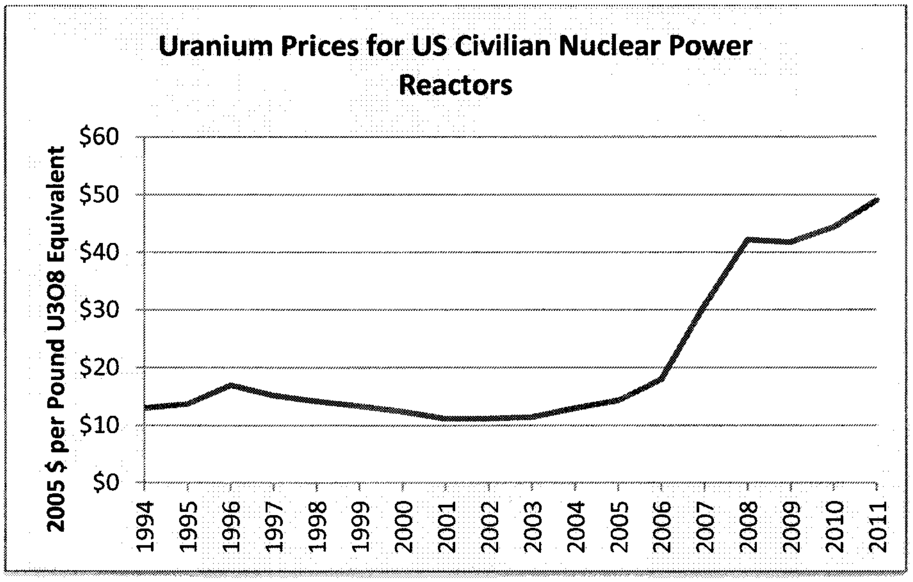

Figure 14

6. System Costs

This section summarizes APS's cost comparisons across the four portfolios it examined and across the sensitivity analyses it conducted.[19] As explained below, **we conclude that retiring coal plants and increasing reliance on renewable energy and energy efficiency can be accomplished at reasonable cost.**

Figure 15 shows the results of APS' base case cost analysis and APS's sensitivity analyses. APS' sensitivity analyses covered natural gas prices, CO_2 emission regulation compliance costs, extension of tax incentives for renewable resources, inclusion of externalities costs, and energy efficiency costs. The low cost and high cost scenarios are bookend cases in which all of the factors analyzed are at their high cost or low cost extremes.

The major lesson to be drawn from this analysis is that within any sensitivity case, variations in cost across portfolios are small. This conclusion is reached by comparing costs across portfolios under a given sensitivity case so that the same assumptions apply to all four

[19] APS's cost analysis includes the carrying costs on existing and future generation, on future transmission over and above APS's Ten Year Transmission Plan, and on capital expenditures on existing generation; fuel costs; purchased power costs; operating and maintenance costs for existing and future generation; energy efficiency and distributed generation program and incentive costs; and power plant emission costs including SO_2 and CO_2. Excluded are costs of existing transmission and existing and future distribution facilities and sales taxes. (APS Resource Plan, p. 90). Costs include environmental compliance costs and integration costs for intermittent renewable energy resources. The plan includes backup capacity and those costs are included in revenue requirements.

portfolios. For example, in the base case, the range of present values of revenue requirements across the four portfolios is about $1 billion or about 2.4% of the base case portfolio cost. This is a small range given the huge uncertainties in any long term projection. APS came to the same conclusion: "The four portfolios analyzed have markedly similar 15-year [net present values] of revenue requirements for the 15-year Planning Period" (APS resource plan, p. 53). (Note that APS provided net present values for the 15 year planning period and for an extended period through 2041; our Figure 15 uses the extended period). APS did not analyze sensitivities of every possible factor such as coal costs, uranium costs, costs of unanticipated pollution control equipment and operation, or slower load growth.[20]

We conclude that, when considering the uncertainties of the many factors influencing costs, APS's analysis indicates that none of the portfolios it examined is significantly more or less costly than any of the others.

When judging long term projections, it is important to keep in mind the inherent error in such forecasts. To illustrate this point, Table 2 compares several projections from the 1992 EIA *Annual Energy Outlook* forecast (reference case) for the U.S. for 2010 with what actually occurred in 2010. While some projections were pretty close to actual outcomes, others were way off (for instance, the amount of renewable energy). Much can happen that was not anticipated, such as recessions, technological change, world demand for fuels, etc.

[20] For example, if APS is required to install selective catalytic reduction (SCR) at Cholla Units 2 and 3 to reduce NOx emissions, the present value of APS's costs for portfolios containing these units could increase by over $100 million (calculated over a 20 year time horizon starting 2017 using a discount rate of 7.95%). See 77 *Federal Register*, July 20, 2012, 42834-42871, Table 19, and APS resource plan, p. 108.

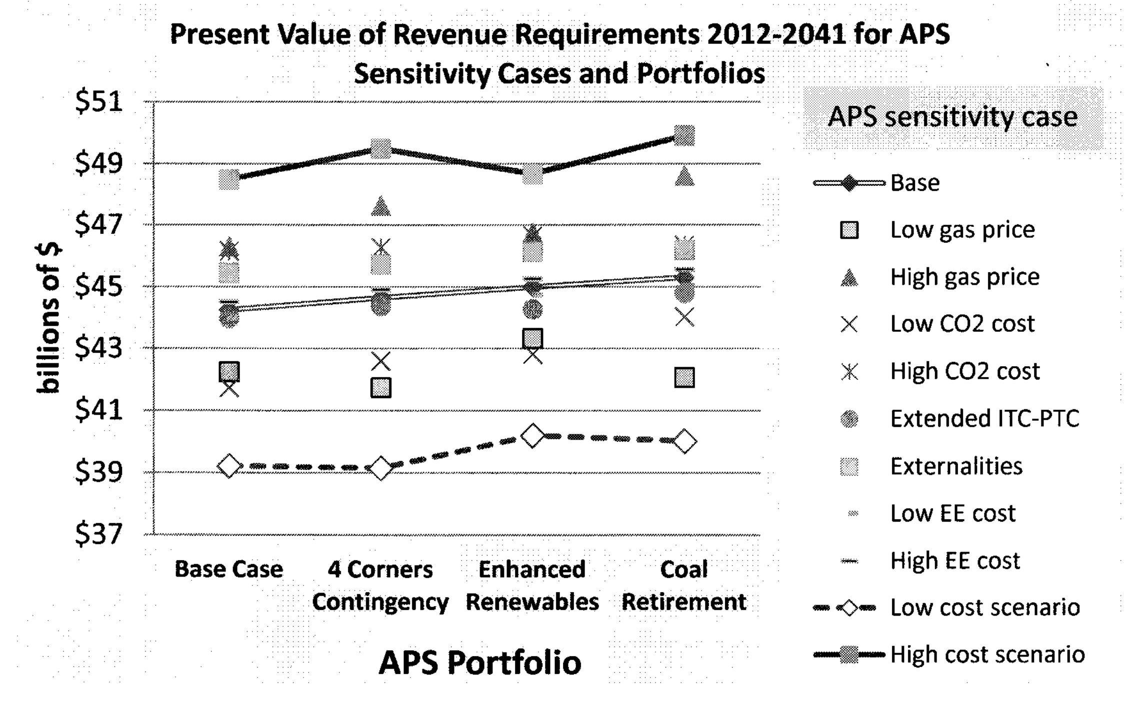

Figure 15

Table 2. The US in 2010 as Seen from the 1992 EIA Annual Energy Outlook (Reference Case)

Factor	EIA AEO 1992 Forecast for 2010	Actual 2010	Forecast as % of actual
Retail electricity sales (GWh)	3,996,000	3,754,493	106%: Fairly close
Natural gas generation (GWh)	765,000	987,697	77%: Underestimated
Coal generation (GWh)	2,317,000	1,847,290	125%: Overestimated
Natural gas price paid by electric utilities (2010 $/MMBtu)	$8.36 (inflated by GDP IPD from 1990 $ to 2010 $)	$5.08	164%: Overestimated
US wind generation (GWh)	11,340	94,652	12%: Huge underestimate
US geothermal generation (GWh)	59,270	15,219	389%: Huge overestimate
US photovoltaic MW	10	2,153*	0%: Completely wrong

* Source: Larry Sherwood, *U.S. Solar Market Trends 2010*, Latham, NY: Interstate Renewable Energy Council, 2011. Grid connected PV only.

Renewable energy is an important component of APS's plan and of our path forward. The effect of adding intermittent renewable resources (photovoltaic and wind energy) is captured by APS in its system cost analyses as summarized in Figure 15, above. Integration costs and additional capacity required to meet peak demand plus a reserve margin are included in APS's system cost analyses. APS conducted system cost analyses where each portfolio: 1) has an aggregate capacity credit sufficient to meet peak demand plus a reserve margin; 2) produces adequate energy to serve customers; and 3) incorporates interactions among resource types – more use of wind energy, for example, will reduce gas generation. As noted above, using more renewable energy does not impose significant additional costs on APS' system.

APS presents a diagram that assigns "firming costs" to wind and solar energy because these resources have capacity credits that are less than their nameplate capacities (see Figure 13 on page 31 of APS's resource plan).[21] The diagram is intended to help APS compare resource options at a general level. However, assignment of "firming costs" to specific resources is inappropriate because meeting capacity needs plus a reserve margin is a **system** requirement, not a requirement of each separate resource.[22] In addition, APS's Figure 13 also requires assumptions about the capacity factors of each technology as fixed costs must be spread over kWh produced. But the capacity factors of natural gas and coal resources vary depending on the resource mix, the demand for electricity at a particular time, and the variable costs of each resource. Consequently, APS's diagram is not informative. We believe that examining the costs of the entire system and comparing costs of alternative portfolios provides far more insight.

7. A More Flexible System with Energy Storage

As the amount of photovoltaic and wind energy increases, the power supply system will need to become more flexible so that grid operators can respond to rapid changes in power output and so that the delivery of energy to consumers can occur when demanded by consumers, regardless of the time the energy was first generated.

The *MIT Study on the Future of the Electric Grid* noted that "flexible resources must be capable of continuously modifying their output, or 'cycling,' to accommodate the variation in

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[21] The term "firming" causes confusion. ICF defines "Firming capacity ... [as] equal to the amount of non-wind generating capacity needed to meet shortfalls in actual wind output with respect to forecast wind output in order to compensate for the forecast uncertainty" (p. 17). Thus, firming, as used in the wind industry, represents capacity needed to make up a shortfall between actual wind output and forecast wind output. See ICF International, *Firming Renewable Electric Power Generators: Opportunities and Challenges for Natural Gas Pipelines*, Report to the INGAA Foundation, March 16, 2011, pp. 14-19. Iberdrola Renewables, "Renewable Energy Delivery, Scheduling, and Firming/Shaping," presentation to the California Public Utilities Commission, Energy Division Workshop, April 23, 2010, slide 13. This is not what APS means by firming. APS focuses on meeting peak demand with a portfolio of resources, including intermittent resources whose capacity credit is less than nameplate capacity.

[22] Along these same lines, APS does not allocate firming costs to specific power plants because their outage rates differ; rather, APS treats capacity needs as a system requirement reflecting the characteristics of the system, namely loss of load probability.

the output of [variable energy resources]" (p. 64).[23] The National Renewable Energy Laboratory identified two components to flexibility – 1) adequate physical flexibility to balance the system, and 2) markets and operational practices to allow access to physical flexibility.[24]

The Regulatory Assistance Project found that "the Western U.S. power grid has existing flexibility in the system to cost-effectively integrate wind and solar resources but, as operated today, that flexibility is largely unused. Integration involves managing the variability (the range of expected electricity generation output) and uncertainty (when and how much that generation will change during the day) of energy resources." [25]

This section addresses one way of increasing the flexibility of the power system – energy storage. Energy storage includes such technologies as batteries, flywheels, compressed air storage, pumped storage, and thermal storage. Additional approaches to increasing flexibility include a greater role for demand response[26] and use of energy imbalance markets.

Energy storage can provide valuable services. For instance, energy storage could enable a utility or third party to store electricity produced by photovoltaics for delivery to customers after sunset when demand for electricity is still high.[27] Energy storage may also allow utilities or third parties to store energy produced by wind turbines during hours of low electricity demand for delivery to customers during periods of high demand. In addition to time-shifting capabilities, energy storage technologies can provide voltage and frequency regulation services during very short periods (a few seconds to a few minutes) that maintain system reliability as solar or wind output fluctuates or as other conditions on the grid affect power quality and reliability. Storage facilities may also reduce integration costs of wind and photovoltaic resources.[28] Examples of storage facilities are listed in the appendix.

However, except for pumped storage, energy storage is not a standard component of utility operations. Most utilities have not yet developed competencies in the application of energy storage within their systems. Consequently, beneficial integration of storage technologies is not well understood. Secondly, work remains to be done to improve performance and standardize the products and services offered by energy storage. And third, some energy storage technologies are expensive.

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[23] MIT Study on the Future of the Electric Grid Cambridge, MA, 2011, http://web.mit.edu/mitei/research/studies/the-electric-grid-2011.shtml.

[24] National Renewable Energy Laboratory, "The importance of flexible electricity supply," Energy Efficiency and Renewable Energy, U.S. Department of Energy, DOE/GO-102011-3201, May 2011.

[25] Regulatory Assistance Project, *Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge, Executive Summary*, report to the Western Governors' Association, 2012, p. 2.

[26] APS's resource plan incorporates 350 MW of demand response in 2027, up from 83 MW in 2012.

[27] The Solana concentrating solar power plant will store heat so that electricity can be produced after sunset.

[28] See Answer Testimony of Rebecca Lim, Colorado Public Utilities Commission, In the Matter of the Application of Public Service Company of Colorado for Approval of its 2011 Electric Resource Plan, Docket No. 11A-869E, June 14, 2012, p. 16.

If these obstacles remain in place, energy storage will be a marginal resource, locked out of utility portfolios. At the present time, a key to advancing the role of energy storage is **early adoption** of storage technologies.

There are significant benefits of early adoption of energy storage by utilities:

- **Learning by doing.** Early adopters can learn how to use the new technologies effectively within their utility systems and solve problems encountered in using new methods. Early adopters gain knowledge not available to lagging firms and they may ultimately become long-term leaders in a particular aspect of their industry.
- **Economies of scale in installation and operation.** Utilities that pursue multiple similar storage projects will be able to standardize installations instead of relying on infrequent custom-designed projects which are likely to have higher average costs.
- **Satisfaction of customer demand for services that can be provided by storage** such as more reliable power supplies or clean energy provided during periods of high demand. For example, the military demands large quantities of renewable energy.[29]
- **Economies of scale in the design and manufacture of storage equipment.** These economies would occur only if there are early adopters.
- **Improved technology.** The energy storage industry will be motivated to improve its technology as demand for storage increases and as feedback from utilities is obtained.

Despite these benefits, monopoly utilities may be reluctant to be early adopters of new technologies. Monopolies may have less incentive to seek out new technologies because there is minimal competitive pressure to expand their areas of expertise.[30] Moreover, traditional utility regulation may send a message to utility managers to avoid innovative changes as innovation could result in disallowances if anything goes wrong or if costs increase because early versions of the new technology are not yet cost competitive.[31]

Additionally, regulated utilities may be reluctant to pursue risky projects as there is no corresponding financial reward if they are successful – rates would still be regulated and any rewards often accrue largely to ratepayers.

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[29] Army Senior Energy Council and Office of the Deputy Assistant Secretary of the Army for Energy and Partnerships. 2009. *Army Energy Security Implementation Strategy*. Washington, DC. Available at: <http://www.asaie.army.mil/Public/Partnerships/doc/AESIS_13JAN09_Approved%204-03-09.pdf>.

[30] W. Sine and R. David, "Environmental jolts, institutional change, and the creation of entrepreneurial opportunity in the US electric power industry," *Research Policy* 32 (2003): 185-207.

[31] Jun Ishii, "Technology adoption and regulatory regimes: Gas turbine electricity generators from 1980 to 2001." Berkeley, CA: University of California Energy Institute, 2004. Rose and Joskow argue that larger utilities may be more likely to be early adopters of new technologies because a small mistake would have less of an impact on profitability and because their larger engineering staffs could better select and apply new technologies: Nancy Rose and Paul Joskow, "The diffusion of new technologies: evidence from the electric utility industry." *Rand Journal of Economics*, 1990: 354-373.

Barriers to energy storage may be less stringent in markets with a regional transmission operator or similar structure. For instance, in West Virginia, the 98 MW Laurel Mountain wind farm and associated 32 MW lithium-ion battery energy storage system began operations in October, 2011. Both the wind and storage components are owned by AES Corporation. The batteries smooth out variations in wind generation and the wind/storage project supplies energy, operating reserve capacity, and regulation service to the PJM interconnection.[32]

A. Transitioning to a more flexible power supply system

A useful way to manage a transition to a more flexible power supply system is to create, implement, modify, and eventually phase out purposeful trials or experiments in which:

- new technologies and practices are demonstrated,
- suppliers and users learn about the new technologies, and
- government, industry, and non-governmental organizations work in a coordinated manner to use and improve new technologies and practices. [33]

The **goals** of this type of trial or experiment should be concerned with:

- Lowering the cost of energy storage technologies
- Improving the performance of energy storage technologies
- Learning-by-doing to advance knowledge about how to best integrate energy storage into the existing grid
- Developing markets for (or otherwise valuing) ancillary and time-shifting services offered by energy storage so that the benefits of storage may be given proper consideration and facility owners can be compensated for the benefits they provide[34]

Policy parameters are also key. A colloquium on commercialization of advanced energy technologies at the Harvard Kennedy School identified several characteristics of a successful set of policies:[35]

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[32] MacDonald, Paul, "Ramping up renewable energy storage," *energyG* March/April (2012), *http://www.altenerg.com/back_issues/marapr2012-story5.htm* . AES Energy Storage, http://www.aesenergystorage.com/

[33] René Kemp, Johan Schot, and Remco Hoogma, "Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management," *Technology Analysis and Strategic Management* 10(2), 1998: 175-195.

[34] See Ethan Elkind, *The Power of Energy Storage: How to Increase Deployment in California to Reduce Greenhouse Gas Emissions*, University of California Center for Law, Energy and the Environment and UCLA Environment and Law Center and Emmett Center on Climate Change and the Environment, 2010.

[35] Venkatesh Narayanamurti, Laura Diaz Anadon, Hanna Breetz, Matthew Bunn, Henry Lee, and Erik Mielke, *Transforming the Energy Economy: Options for Accelerating the Commercialization of Advanced Energy Technologies*, Cambridge, MA: Harvard Kennedy School, Belfer Center for Science and International Affairs, 2011. Available at: http://belfercenter.ksg.harvard.edu/files/ETIP_Workshop_Report_Feb_2011_2.pdf.

- Policies must be consistent over a long term – commercialization of new technologies does not happen in one year.
- Demonstration projects should be focused on technologies with commercial potential, including potential under different economic conditions than exist today.
- Policies should address the conflicts between private intellectual property and making information public.
- An exit strategy for specific projects and for general support should be developed, based on the performance benchmarks.
- Cost sharing between the private sector and the public sector (e.g., ratepayers) will typically be needed; we note that both sectors would typically benefit.
- Programs should define the success metrics, keeping in mind that there will be failures; failures often receive more publicity than success.
- A wide range of competing technologies should be pursued. However, a policy ought to be focused on a well-defined set of issues or solutions and not be so broad as to dilute its effect.

B. State energy storage policies

Experience in other states provides some guidance on overcoming obstacles to early adoption. Three examples are discussed below – the Colorado Public Utilities Commission's case-by-case approach to early adoption, New York's efforts to encourage commercialization of energy storage, and California's incipient effort to set energy storage targets. These policies vary in several significant ways:

- Scope and focus – are they incremental or do they adopt a long term goal? Do they focus only on utilities or do they seek to accelerate advances in other parts of the storage industry, including research?
- Learning – how do the policies expand utility competencies regarding integration of energy storage technologies into the grid and how do they also address learning in other sectors such as manufacturing of storage devices?
- Utility cost recovery – how would regulated utilities recover their energy storage facility or energy storage service costs?
- Receptivity to riskier innovations – does the policy encourage or discourage investments in riskier projects?

The Colorado Public Utilities Commission has established a general process for reviewing Xcel Energy's Innovative Clean Technology Program that, so far, encourages early adoption of energy storage projects.[36] The Commission stated that "We affirm ... proactive support of investments in innovative clean technologies, ..., so that this practice over time becomes institutionalized with [the utility's] ordinary course of business" (Decision No. C09-0889, p. 7). The Colorado process includes the following components:

[36] Colorado Public Utilities Commission Decision No. CO9-0889 (Docket No. 09A-015E), July 1, 2009.

- Each proposed project would be reviewed by the Commission on a case by case basis.
- The Commission would issue an accounting order authorizing deferred accounting of each approved project-specific cost; the order would convey a presumption of prudence for cost recovery in the next rate case.
- In each project proposal, the utility must address handling of anticipated intellectual property resulting from the project.
- The utility is to set up a stakeholder review process to assess potential projects prior to submitting an application.

In addition to Innovative Clean Technology projects, the Colorado Commission may also review energy storage projects in its resource planning process, including resource procurement.[37]

New York seeks to advance the integration of energy storage into power systems by focusing on commercialization of energy storage. The New York State Energy Research and Development Authority (NYSERDA) is pursuing commercialization through the New York Battery and Energy Storage Technology (NY-BEST) Consortium.[38] NY-BEST is a non-profit corporation funded, in part, through New York's participation in the Clean Air Interstate Rule. The purposes of the programs are to:[39]

- "Accelerate the commercial introduction of energy storage technology in New York;
- Build the human capital and expertise to sustain a vibrant commercial energy storage industry in New York; and
- Leverage seed resources of approximately $25 million to create a sustainable organization that provides value to its members and to New York State. The objective is for NY-BEST to become operationally self-sufficient."

The consortium draws upon expertise from the U.S. Department of Energy, universities, Brookhaven National Laboratory, and energy storage companies. The program's initial benefits were expected to include success stories, technology transfer activities, development of testing capabilities, research funding, publications, inventions and licenses, and commercialization of technologies and companies.[40] In 2010, funding was provided for:[41]

- Commercializing batteries for smoothing intermittent resources
- Integrating batteries with renewable energy generation

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[37] Code of Colorado Regulations, 4 CCR 723-3, Section 3604(k); C.R.S. 40-2-123, Paragraph 1(a); and Colorado Public Utilities Commission, Decision No. C08-0929, Docket No. 07A-447E, September 19, 2008, paragraphs 370 and 376.
[38] http://www.ny-best.org/.
[39] http://www.ny-best.org/About_NY-BEST.
[40] NYSERDA, New York Battery and Energy Storage Technology Consortium, Annual Report 2009-2010, March 2010.
[41] *Ibid.*

- Developing improved batteries and ultra-capacitors
- Developing methods to recycle and reuse batteries

California's Assembly Bill 2514 requires the California Public Utilities Commission to conduct a proceeding to determine appropriate targets, if any, for each load-serving entity to procure viable and cost-effective energy storage systems to be achieved by December 31, 2015, and by December 31, 2020. The Commission may consider a variety of policies to encourage the cost-effective deployment of energy storage systems. The Commission began a rulemaking proceeding in December 2010 but has not yet adopted a process to implement AB 2514.

C. Energy storage policy process for Arizona

We recommend that the Commission conduct a series of workshops that would lead to rulemaking or development of other policies to encourage early adoption of energy storage. Workshops should be used to obtain information from individuals knowledgeable about programs in other states, from the energy storage industry, from National Laboratories, from utilities with energy storage experience, from other utilities, and from other stakeholders. A sample outline for a storage workshop is presented in Box A below.

Box A. Sample Outline for a Storage Workshop

A. Potential uses of energy storage technologies
B. Potential benefits of energy storage
C. Energy storage technologies
    1. Commercially available technologies
    2. Technologies suitable for demonstration projects and applications
    3. Other technologies
D. Current costs of energy storage technologies
E. Experience with specific energy storage projects
    1. Lessons learned
    2. Cost recovery
    3. Regulatory review and approval processes
F. Policy elements
    1. Establishing utility energy storage trials or "experiments"
    2. Goals: lowering costs, improving performance, expanding utility competencies with regard to integration of storage technologies, developing markets for storage services, other goals
    3. Parameters: time horizon, types of technologies to be encouraged, exit strategies, funding sources and amounts, success metrics, other parameters
    4. Policy design framework: scope (incremental v. long term), focus (on utilities or on storage industry generally), learning (expanded utility competencies, technological improvements, development of storage service markets), cost recovery, risk tolerance
G. Rulemaking or other appropriate action

8. Managing the Risk of Water Scarcity

APS's resource plan provides a detailed, comprehensive analysis of the water demands of its existing plants and future generation portfolios. In fact, APS' evaluation of water impacts is more advanced than many other western electric utilities' approaches to assessing current and future water needs. In the following sections, we summarize APS' analysis of water impacts resulting from the four portfolios; review the economic value APS assigns to water; and highlight the benefits of advancing water-efficient sources of energy which can serve as a hedge against the risk of short- or long-term drought.

A. Summary of water use

Today, APS's electricity generation consumes about 53,635 acre feet (AF) of water each year (APS Resource Plan, ATT-94). Table 3 shows the annual volume of water consumption at power plants in which APS has an ownership share and which consume at least 1,000 AF per year. Note that the table pertains to water use for the entire plant, not just APS's share.

Under all portfolios analyzed by APS, water intensity (gallons per MWh) of APS' power production decreases. This decrease is due to several key factors, as noted in the resource plan:

- APS' plan to install dry cooling on any new combined cycle gas units (p. 116);
- The pending retirement of Four Corners Units 1-3 (p. 117); and
- The expansion of APS' DSM and renewable energy resources, which, except for the Solana plant, generally use little or no water (p. 118).

In addition, APS notes (p. 117) that it would evaluate a hybrid wet-dry cooling system for any new thermal plants even though no coal or nuclear additions are contemplated in the current resource plan.

While the water intensity of electricity generation declines under all future portfolios, total future water demands vary considerably among portfolios. Under the Base Case and the Enhanced Renewable Energy portfolios, the total volume of water consumed by APS power plants increases by 6,096 AF and 3,690 AF, respectively, by the year 2027. The Coal Retirement portfolio provides the most substantial reductions in water use, reducing the volume consumed (relative to current use) by 16,617 AF in 2027. This volume is not inconsequential; one AF can meet the annual needs of 2 – 4 urban households.[42]

[42] In 2008, single-family residential use was 123 gallons/person/day in the City of Phoenix, or 0.14 AF/person/year. (Western Resource Advocates, 2010. *Arizona Water Meter*). Typically only half of the water "used" in a household is actually consumed. In Phoenix, 55% of a residence's water is used indoors and is typically non-consumptive, and 45% is used outdoors and is consumptive (City of Phoenix, 2011. *2011 Water Resources Plan*. Figure 3-5).

Table 3. Water sources and annual consumption for power plants using 1,000 acre feet or more*

Power plant	APS share of power plant (MW)	Primary water supply	Annual water consumption (acre feet)
Cholla	62%	Cholla Reservoir (Groundwater)	15,720
Four Corners	38%	San Juan River/Morgan Lake	23,619
Palo Verde	29.1%	Recycled Wastewater	73,171
Redhawk	100%	Recycled Wastewater	3,399
West Phoenix	100%	Groundwater	2,288
Navajo	14%	Lake Powell (Colorado River)	26,300

* Water consumption pertains to entire plant, not just APS's share. Source of data for all plants except Navajo Generating Station (NGS): APS, 2012. Resource Planning Information for the Historical Year 2011, filed in Arizona Corporation Commission Docket No. E-00000A-11-0113, March 30, 2012. p. 59; and APS, 2012 Integrated Resource Plan. Source of data for water supplies and consumption at NGS: EIA, Form 767 for 2005.

In Arizona and the Southwest, most water supplies are fully- or over-allocated, and meeting municipal, agricultural, industrial, and environmental water needs is a challenge. Arizona relies on groundwater, recycled water, and surface water supplies such as the Colorado River. The Colorado River provides a critical source of renewable water to Arizona farms and cities; it also serves as an apt example of the challenge of meeting existing and future demands, particularly under the projected impacts of future climate change. In the last decade, average Colorado River basin-wide water use equaled or exceeded available flows (see Figure 16);[43] Lake Mead and Lake Powell regulate runoff and moderate the impact of droughts, but storage in the lakes fell to 55% of capacity in 2010.[44] Scientists project that climate change will reduce Colorado River flows by 5 – 20% by mid-century,[45] exacerbating existing challenges. In response to ongoing drought, Colorado River basin states, the federal government, and key stakeholders negotiated changes to Colorado River laws in 2007 that outline how shortages will be shared by Arizona, the other Colorado River basin states, and Mexico.

In sum, as urban populations (and water demands) grow and short- or long-term drought reduces available supplies, water is likely to become scarcer and more expensive than it is today. Any reduction in water use by the energy sector – as with other consumers – helps alleviate this scarcity.

[43] Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study, Interim Report No. 1, Status Report,* 2011. Figure 2. Available at http://www.usbr.gov/lc/region/programs/crbstudy/Report1/StatusRpt.pdf
[44] U.S. Bureau of Reclamation. Lower Colorado River operations schedule. http://www.usbr.gov/lc/region/g4000/hourly/rivops.html (accessed April 16, 2010).
[45] Hoerling, M., D. Lettenmaier, D. Cayan, and B. Udall. 2009. "Reconciling projections of Colorado River streamflow." *Southwest Hydrology* 8:20-21, 31.

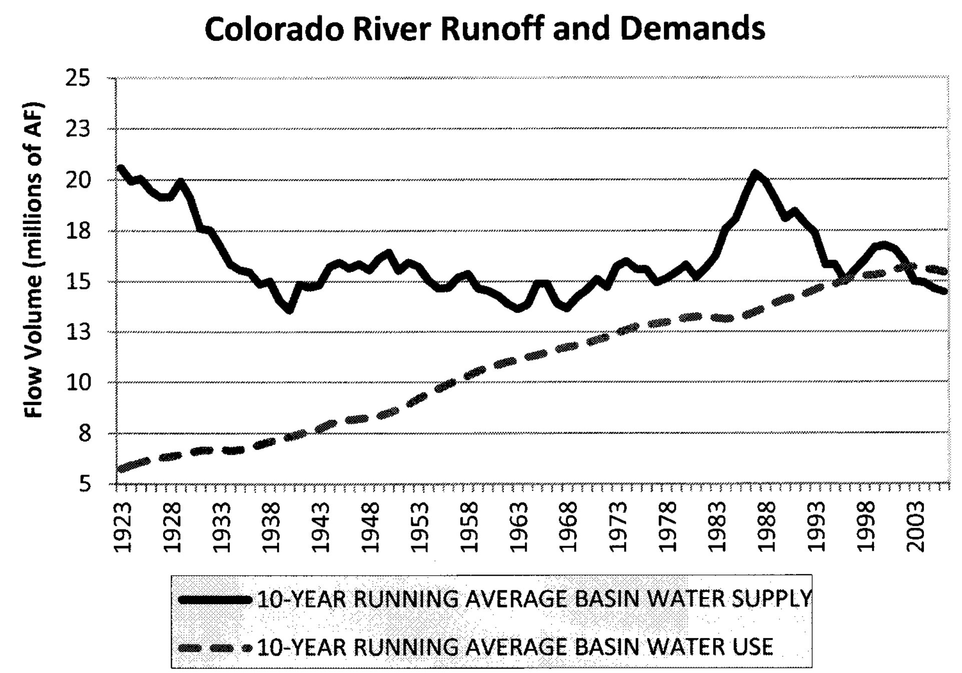


Figure 16

B. Market value of water

APS is among the first utilities to include a monetary value of the water used for electricity generation in its planning process. In general, the market value of water depends on its location, the seniority of the water right, competing uses, and the general scarcity of water supplies. A senior water right in an urban area, for example, is likely to be worth considerably more than a more junior right in a rural area, particularly if the alternative uses are primarily agricultural. Therefore, the value of APS' water may vary greatly among power plants.

APS developed a water value based on the cost of purchasing recycled water for the Redhawk Power Plant (Figure 17).[46] Although this is a reasonable approach to monetizing the water used for electricity generation, it does not reflect the potential for water values to change dramatically over time. In Colorado, for example, water prices rose rapidly in 2002 – 2003, when Colorado experienced severe drought (Figure 18).[47] Since then, prices have fallen, but have remained considerably higher than pre-drought prices. Robust water markets are rare; as a result, there is little statistical analysis of the relation between drought and water prices. However, growing demands coupled with potential drought mean that water prices –

[46] Data for the figure are from p. 136 of APS's resource plan.
[47] Most of the transactions occurred in the Colorado-Big Thompson market, one of the few well-functioning water markets in the West.

and the opportunity cost of continuing to use water for power generation – are likely to rise in the future, and possibly at a non-linear rate.

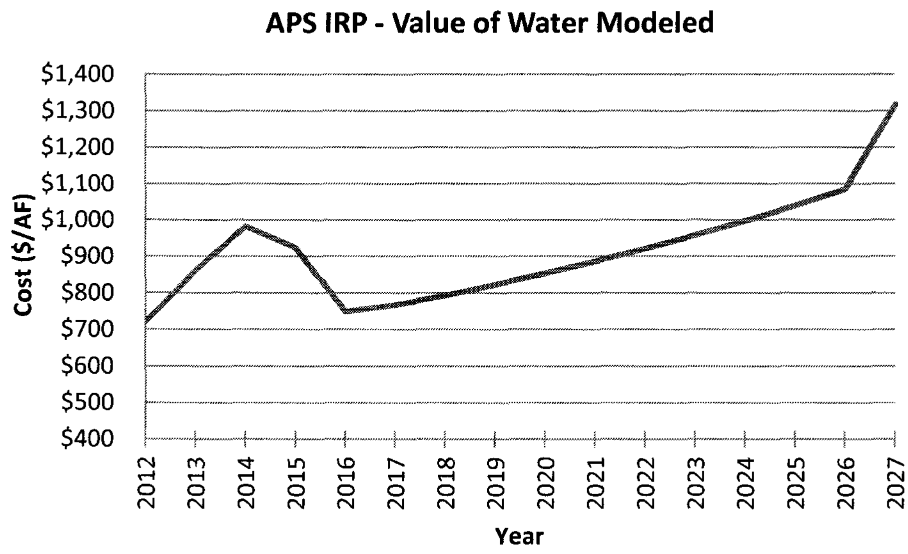


Figure 17

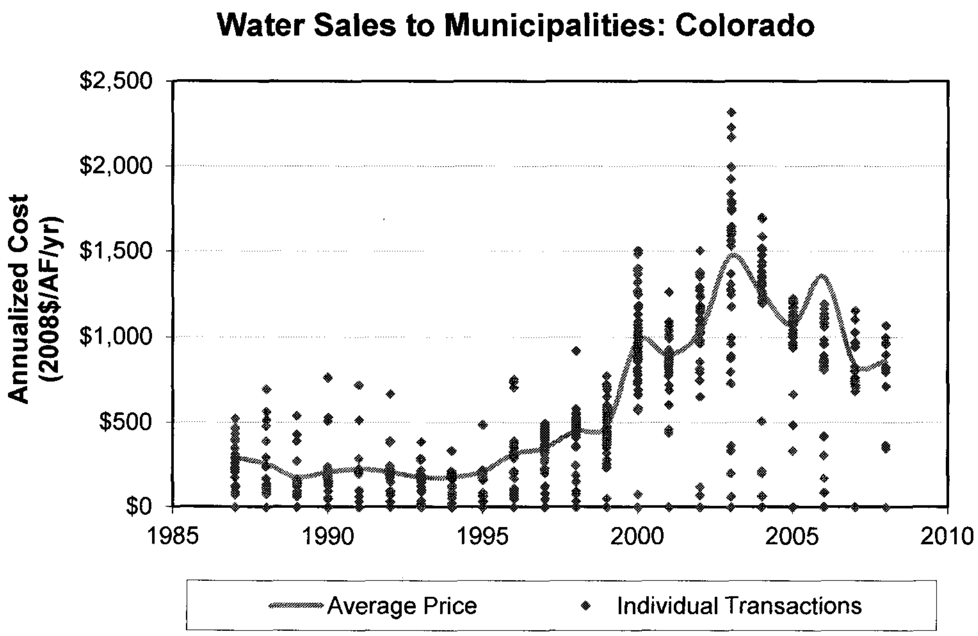


Figure 18

C. Hedging against water scarcity with low water use resources

Drought affects the electricity sector in several ways: it can lead to increased demands for power, reduce hydroelectric generation, reduce water available for cooling thermoelectric facilities, and increase the temperature of water used for cooling thermoelectric plants, effectively reducing their operating efficiency. According to one analysis, "impacts from drought manifest themselves most often economically, in terms of increased costs that can significantly impact local economies," while power shortages are rare.[48] APS reports having never experienced a forced outage at a thermoelectric power plant due to water shortages.[49]

However, the impacts of climate change mean that, in many river basins in the Southwest, droughts are likely to be more frequent and more intense in the future.[50] Recent droughts in Texas and Australia, described in the Appendix, appear to be more severe than historical droughts of record.[51]

Reducing the total volume of water required for electricity generation provides a hedge against water scarcity. Water-efficient resources, including energy efficiency, some renewable energy technologies, and conventional steam generation and concentrating solar power generation that rely on dry cooling, can help manage the risks of future water shortages.

Several strategies will help reduce the likelihood that Arizona will see energy-water conflicts like those that occurred in Texas and Australia. These strategies include providing water data in resource plans, adequately valuing the water used for current and future energy generation, and hedging against drought with water-efficient resources. This last strategy is essential: wind power, solar photovoltaics, energy efficiency, and dry-cooled thermoelectric plants all reduce the water needs of the electricity sector. Renewable resources of energy have no greenhouse gas emissions, and therefore do not contribute to climate change, one of the driving forces behind more frequent and more intense droughts. By reducing greenhouse gas emissions and, in many cases, by requiring no water, renewable sources of energy and energy efficiency provide both mitigation and adaptation benefits.

In conclusion, water is a scarce resource in Arizona, and is likely to become more valuable in the future as demands grow and water supplies are reduced by short- or long-term

[48] Argonne National Laboratory, *Analysis of Drought Impacts on Electricity Production in the Western and Texas Interconnections of the United States*. ANL/EVS/R-11/14, 2011, p. 12.

[49] Argonne National Laboratory, *Analysis of Drought Impacts on Electricity Production in the Western and Texas Interconnections of the United States*. ANL/EVS/R-11/14, 2011, p. 11.

[50] *Global Climate Change Impacts in the United States*, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

[51] The 2010 – 2011 Texas drought was the most severe 1-year drought on record, though other multi-year droughts may have had greater overall severity. John Nielsen-Gammon, "The 2011 Texas Drought: A Briefing Packet for the Texas Legislature," 2011, http://www.senate.state.tx.us/75r/Senate/commit/c510/handouts12/0110BI-JohnNielsen-Gammon.pdf.

drought. Therefore, in making a determination on acknowledgement of APS's resource plan, the Commission should bear in mind that:

1) The coal retirement portfolio saves the greatest amount of water of the portfolios investigated; and
2) Energy efficiency, water-efficient renewable resources such as wind and PV, and dry-cooled steam power plants are a hedge against the risk of drought.

9. Evaluation of APS's Resource Plan

Creating a wide range of options and evaluating those options under uncertainty are essential features of a resource plan. We commend APS for the high quality of its resource planning analysis -- APS analyzed widely different and imaginative options and investigated the sensitivities of those options to a range of cost assumptions. In addition, APS's analysis of water issues leads the industry. APS's 2012 planning analysis, thus, sets a high standard for resource plans to be filed by all utilities going forward.

The resource planning rule sets forth several criteria for evaluating a utility's resource plan. Table 4 summarizes our evaluation of the APS plan along these criteria (except for transmission reliability and coordinating efforts with other load serving entities which we did not examine).

While APS prefers its base case portfolio, **we conclude that a new portfolio that blends the coal plant retirement and enhanced renewable energy portfolios should be pursued**:

- ✓ It would result in reasonable costs, i.e., in costs that are not significantly higher than the costs of APS' base case portfolio, given the large uncertainties around factors that affect future costs, including factors that APS did not analyze using sensitivity analysis or other methods.
- ✓ It hedges against fossil fuel price risk
- ✓ It hedges against water scarcity
- ✓ It best protects the environment and human health
- ✓ It reflects the priorities of many of APS' customers who desire clean energy resources at reasonable cost

Table 4. WRA Evaluation of APS's Resource Plan per A.A.C. R14-2-704(B) Criteria

Criterion	Evaluation

Total cost	• Costs of all portfolios evaluated by APS are about the same within any sensitivity case
	  ○ Cost projections are subject to potentially large errors
	  ○ APS did not examine all cost uncertainties such as uncertainties about capital costs of various resource options or additional pollution control equipment (e.g., SCR at Cholla)

Demand factors	• APS plans to comply with the energy efficiency standard • APS projects a return to historic load growth (see appendix to these comments) but its plan is flexible and may accommodate different growth rates

Supply alternatives	• APS considered a range of supply-side portfolios including:
	  ○ increases in renewable energy beyond the renewable energy standard
	  ○ coal plant retirements

Uncertainty	• Forecasts are subject to large uncertainties; future fuel prices are highly uncertain • APS modeled a variety of sensitivity cases • APS's portfolios allow for flexibility in the timing and size of resource additions • By going beyond the base case portfolio and increasing the role of renewable energy and decreasing the need for fossil fuel generation, exposure to uncertain fuel prices would be reduced • APS will hedge against the risk of water scarcity by using dry cooling on new combined cycle plants; greater use of renewable energy and energy efficiency will also strengthen the hedge against the risk of water scarcity
Reliability of power supplies	• APS includes a reserve margin based on loss of load probability of one day in 10 years (APS Resource Plan, p. 75) • Adding significant energy storage could improve system reliability • Water efficient resources reduce the risk of power curtailments due to drought
Environmental impacts	• Coal plant retirement greatly reduces emissions of CO_2, SO_2, and NOx and hence reduces health and environmental impacts of power generation • Extensive deployment of renewable energy and energy efficiency reduces air emissions
Consideration of all relevant resources and risks	• APS's portfolios and sensitivity analyses provide an informative range of options under a variety of conditions • See other items in this table

Best interest of customers, and best combination of cost and risk	• A new portfolio that blends the coal plant retirement and enhanced renewable energy portfolios meets these criteria:
	  ○ It would not impose significant additional costs relative to other portfolios, especially given the huge uncertainties of future costs
	  ○ It hedges against fossil fuel price risk
	  ○ It best protects the environment and health
	  ○ It hedges against the risk of water scarcity
	  ○ It reflects customer priorities

10. Conclusions and Recommendations

We draw the following conclusions from our review:

- Long-term forecasts are subject to error.

- APS investigated four rather different portfolios and, despite their differences, the costs vary only slightly from one to the next.
- Coal-fired power plants impose significant health and environmental costs.
- Managing the environmental and health risks of coal generation by greatly reducing coal generation has minor cost implications as indicated by the small cost differences among the four portfolios APS examined.
- Coal and uranium prices are increasing and natural gas prices have been very volatile.
- Conventional generation exposes APS and its customers to large uncertainties over future fuel prices.
- Meeting the Commission's energy efficiency standard, as planned by APS, will reduce APS's costs and will reduce air emissions from fossil-fuel power plants.
- Energy efficiency and most renewable energy resources require no fuel and thus provide a hedge against high fuel prices.
- APS's coal retirement portfolio saves the greatest amount of water among all the portfolios it investigated.
- Energy efficiency, water-efficient renewable resources such as wind and PV, and dry-cooled thermoelectric power facilities are a hedge against the risk of water scarcity.
- Energy storage facilities can add value to wind and solar energy projects.

☞ **We recommend that the Commission approve APS's 3 year action plan.** The action plan elements pertain to short lead-time resources:

- Continued deployment of utility scale PV and small renewable energy generation projects consistent with the 2009 rate case settlement
- Continued deployment of distributed renewable energy resources
- Deployment of energy efficiency resources to meet the efficiency standard
- Planning for new gas generation as early as 2016 depending on uncertain load growth and whether all planned renewable resources and energy efficiency resources are deployed.

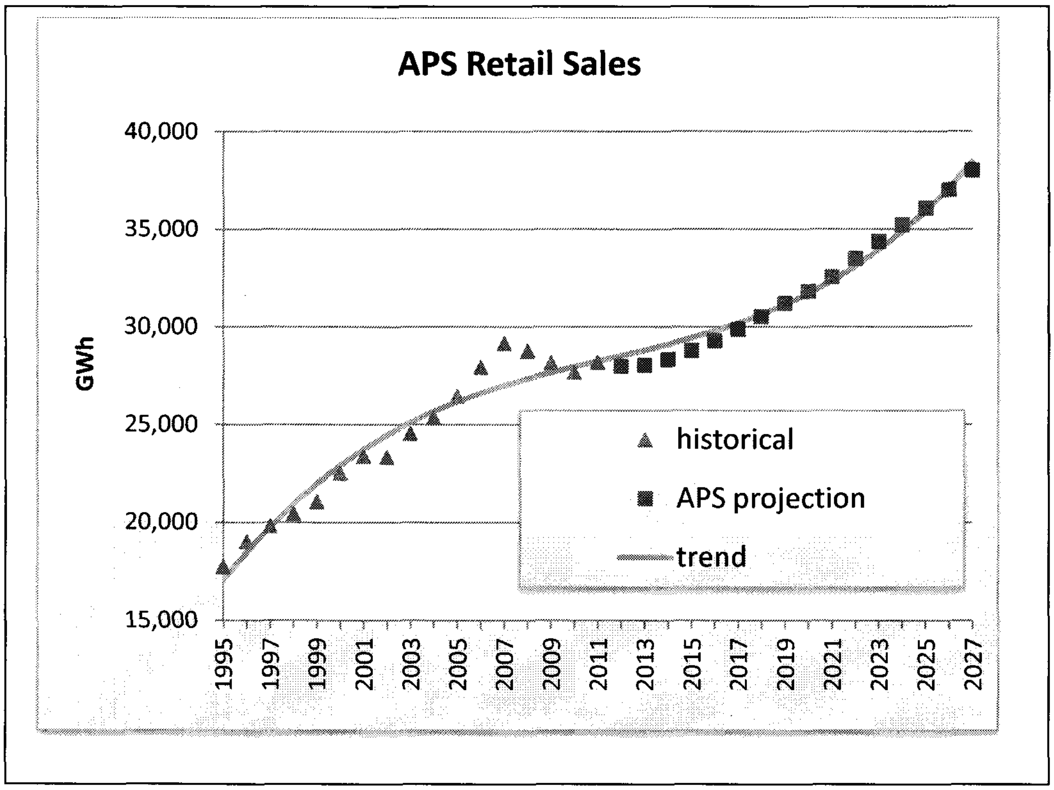
☞ **We recommend that the Commission acknowledge APS's enhanced renewable energy and coal retirement portfolios** for the reasons set forth in Section 9, above. Accordingly, the Commission should direct APS to prepare an option for the next resource plan filing that blends the enhanced renewable energy and coal retirement portfolios. Most, if not all, coal resources should be retired within 15 years and replaced with a mix of renewable energy and gas generation.

☞ **We recommend that the Commission proceed with a workshop process to develop a policy to promote early adoption of energy storage.**

Appendix

1. APS retail sales over time

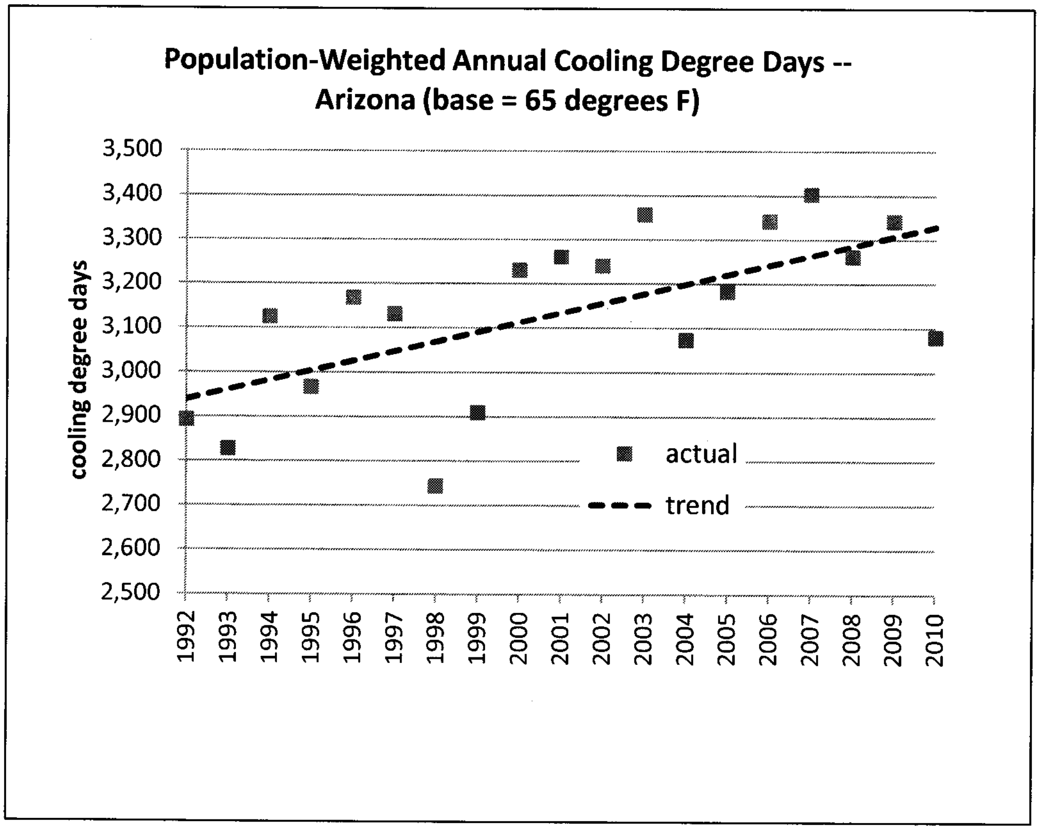
APS forecasts a return to historical growth rates as shown in the figure below. APS's resource plan does not lock in large new resources at this time and is sufficiently flexible to accommodate revisions in its load forecast.

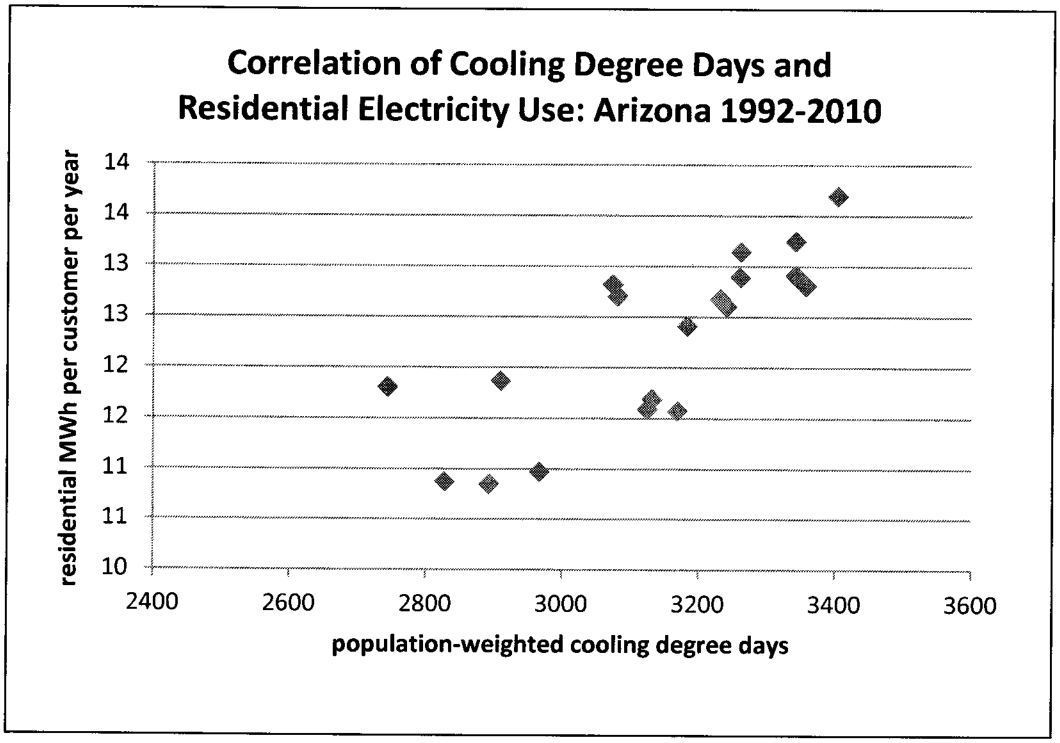


2. Weather

Cooling degree days are a measure of hot weather and reflect the demand for air conditioning. The upper graph on the next page shows the upward trend in cooling degree days in Arizona. The lower graph shows the correlation of Arizona residential electricity use per customer and cooling degree days – the hotter the weather, the greater the air conditioning load.[52] As Arizona weather gets hotter, electricity use will increase.

[52] Cooling degree data are from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service. Various dates. *Heating and cooling degree data.* Historical Climatology Series 5-2. Available at: <http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html#52updates>. The data are weighted by population. Electric usage data are from: Energy Information Administration, *Electric Power Annual 2010*. State historical tables for 2010. Excel spreadsheets available at: <http://www.eia.gov/cneaf/electricity/epa/epa_sprdshts.html>.


Population-Weighted Annual Cooling Degree Days -- Arizona (base = 65 degrees F)
cooling degree days
3,500
3,400
3,300
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
actual
trend


Correlation of Cooling Degree Days and Residential Electricity Use: Arizona 1992-2010
residential MWh per customer per year
14
14
13
13
12
12
11
11
10
2400
2600
2800
3000
3200
3400
3600
population-weighted cooling degree days

3. Effects of drought on electricity production in Texas and Australia

In 2011, Texas experienced one of the most extreme droughts in the state's history. The drought affected all sectors of society – agriculture, municipal users, and the energy sector. Only 24 MW of power was curtailed because of water shortages in 2011,[53] though one large power plant reportedly curtailed generation at night in order to maintain sufficient water supplies for cooling during peak daytime demands.[54] In December, 2011, sources of cooling water supplies were at historic lows for almost 11,000 MW of generating capacity,[55] and had drought conditions not eased, Texas regulators projected that up to 3,000 MW of capacity could have been curtailed by May, 2012,[56] with potentially large amounts of forced outages.

Specifically, the following occurred in Texas in 2011:

- Below average rainfall (drought) is associated with higher temperatures.[57] Higher temperatures, in turn, contribute to higher electricity demands due to air conditioning loads; Texas saw record electricity demands.[58]
- Peak summer electricity demands coincided with the height of the drought. Electricity prices rose, and while no causal relationship has been demonstrated, by restricting generation and/or raising demand, the drought may have contributed to high prices.
- To maintain reliability, power plants extended pipelines in order to access new sources of water or lowered lake levels, sought additional water rights, and brought several units totaling 470 MW of capacity out of mothballed status.[59]
- The Texas Commission on Environmental Quality suspended or curtailed over 1,200 water rights, but did not suspend out-of-priority (junior) water rights for municipal or power generation needs.[60]

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[53] Electric Reliability Council of Texas (ERCOT), 2011. "ERCOT NEWS: October Board Meeting Highlights," available at: http://www.ercot.com/news/press_releases/print/451 .

[54] K. Galbraith, "Drought could pose problems for Texas power plants," *The Texas Tribune,* September 16, 2011.

[55] Electric Reliability Council of Texas (ERCOT). December, 2011. *Seasonal Assessment of Resource Adequacy for the ERCOT Region Winter 2011-2012,* http://www.ercot.com/content/news/presentations/2011/SARA%20-%20Winter%202011-12_V7.pdf.

[56] Electric Reliability Council of Texas (ERCOT), 2011. "ERCOT NEWS: October Board Meeting Highlights," available at: http://www.ercot.com/news/press_releases/print/451 .

[57] J. Nielsen-Gammon, Texas State Climatologist, Testimony before the Texas Senate Business & Commerce Committee, January 10, 2012, http://www.senate.state.tx.us/75r/Senate/commit/c510/handouts12/0110BI-JohnNielsen-Gammon.pdf

[58] See, e.g. ERCOT, August 2, 2011. News Release: Power watch - conservation needed, http://www.ercot.com/news/press_releases/show/411.

[59] J. Fainter, Association of Electric Companies of Texas (AECT), "Drought impacts on electric generation," Testimony before the Texas Senate Business & Commerce Committee, January 10, 2012, http://www.senate.state.tx.us/75r/Senate/commit/c510/handouts12/0110-AECT.pdf; and T. Doggett, "Impact of drought conditions on electric generation," Testimony before The Texas Senate Business & Commerce Committee, January 10, 2012, http://www.senate.state.tx.us/75r/Senate/commit/c510/handouts12/0110-ERCOT.pdf

[60] B. Shaw, Texas Commission on Environmental Quality, Testimony before the Texas Senate Business & Commerce Committee, January 10, 2012. http://www.senate.state.tx.us/75r/Senate/commit/c510/handouts12/0110-TCEQ.pdf.

Several factors may have exacerbated the impact of drought on the electricity sector in Texas. For example, Texas' grid covers a smaller geographic region than the western grid, and drought impacted power plants throughout the state in 2011. A key mitigating factor may have been the 10,000 MW of wind capacity in Texas. Because wind turbines use no water, Texas' wind generation may have mitigated the impacts of drought on the power sector. Importantly, Texas, like Arizona and other western states, has experience managing droughts, but the drought of 2011 led to unprecedented impacts on the power sector.

Southeastern Australia experienced what has been called a "one in a thousand year drought" from roughly 2000 to 2009.[61] Like the drought in Texas, it affected all sectors of society – municipal, agricultural, environmental, and industrial. Water shortages appear to have had a much greater effect on both hydroelectric and thermoelectric power facilities in Australia than in Texas, likely a result of the duration of drought. Specifically,

- Drought conditions plagued the country for several years, peaking in 2007.
- A key reservoir on the Brisbane River (Wivenhoe Reservoir) provides water for both municipal needs in the city of Brisbane (population of over 2,000,000) and power plants. Electricity generation at the two power plants, Tarong (1,400 MW coal unit) and Tarong North (443 MW coal unit), was curtailed in 2007 in order to protect municipal supplies. As a corollary result, production and employment at the coal mine that feeds the Tarong plants were also cut.
- A recycled water pipeline (Western Corridor Recycled Water Scheme) was constructed to transfer recycled water to the Wivenhoe Reservoir, and managers of the Tarong plant built facilities to capture storm water and reclaim water from the site's ash collection facility, all at a cost.
- Operations at a third coal plant, Swanbank B (500 MW), were also curtailed.[62]
- Electricity prices soared.

Southeastern Australia has a climate similar to that of the Southwestern U.S., and experiences regular droughts and water scarcity. Like Texas, the recent drought had unprecedented impacts on the electricity sector.

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[61] J. Vidal, "Australia suffers worst drought in 1,000 years," *The Guardian,* November 7, 2006, http://www.guardian.co.uk/world/2006/nov/08/australia.drought

[62] All of the power plants affected – Tarong, Tarong North, and Swanbank B rely on wet-recirculating cooling systems. Australia National Water Commission, Alan Smart and Adam Aspinall. *Water and the Electricity Generation Industry: Implications of Use*. Waterlines Report Series No. 18, August 2009, http://www.nwc.gov.au/__data/assets/pdf_file/0010/10432/Waterlines_electricity_generation_industry_replace_final_280709.pdf.

4. Examples of Energy Storage Projects

Project	Technology	State	Owner	MW	Paired Grid Resource	Services Provided
Johnson City	Li-ion battery	NY	AES Energy Storage	8	NA	Frequency regulation, reserve capacity
Laurel Mountain	Li-ion battery	WV	AES Energy Storage	32	98 MW wind project	Frequency regulation, ramping, operating reserve capacity
Battery Energy Storage System	Nickel-cadmium battery	AK	Golden Valley Electric Association	27	NA	Reserve capacity (for generation or transmission outages)
Metlakatla Battery Energy Storage System	Lead acid battery	AK	Metlakatla Light and Power	1	NA	Reserve capacity, frequency regulation, voltage support
Lanai Sustainability Research	Advanced lead acid battery	HI	Castle & Cook	1.125	1.5 MW PV	Ramping, renewables capacity firming, frequency regulation
PNM Prosperity Energy Storage Project	Advanced lead acid battery	NM	PNM	0.25	500 kW PV	Smoothing, voltage support, time shifting, peak shaving,
Beacon Power	Flywheel	NY	Beacon Power	20	NA	Frequency regulation
Blenheim-Gilboa	Pumped storage	NY	New York Power Authority	1,160	NA	Time-shifting, reserve capacity

Sources: US Department of Energy and Sandia National Laboratories, *DOE Energy Storage Database (beta),* http://www.energystorageexchange.org/projects. AES Energy Storage, "AES Energy Storage Projects," http://www.aesenergystorage.com/projects.html. Paul MacDonald, "Ramping Up Renewable Energy Storage," *energyG* March/April (2012), *http://www.altenerg.com/back_issues/marapr2012-story5.htm*. Golden Valley Electric Association, "Battery Energy Storage System (BESS)," http://www.gvea.com/energy/bess. Metlakatla Power and Light, Emergency Battery Energy Storage System Replacement Grant Request to Alaska Commerce, Community and Economic Development Agency," (AS 37.05.317), April 2008 . George Hunt and Joseph Szymborski, "Achievements of an ABSOLYTE® Valve-Regulated Lead-Acid Battery Operating in a Utility Battery Energy Storage System (BESS) for 12 Years," Absolyte Technologies Professional Paper, Battery Energy Storage System, 2010. Abbas Akhil and Ron Pate, "Lanai Battery Project – Background and Lessons Learned," HCEI Electricity Working Group Meeting, November 28, 2011. Steve Willard, "Renewable Energy and the Need for Energy Storage," presentation to the New Mexico Society of Professional Engineers, February 24, 2012. Matt Lazarewicz and Judith Judson, Beacon Power Corporation, "Performance of First 20 MW Commercial Flywheel Frequency Regulation Plant," ESA 2011 Annual Meeting, San Jose, CA, June 7, 2011. New York Power Authority, "Blenheim-Gilboa Pumped Storage Project," http://www.nypa.gov/facilities/blengil.htm.