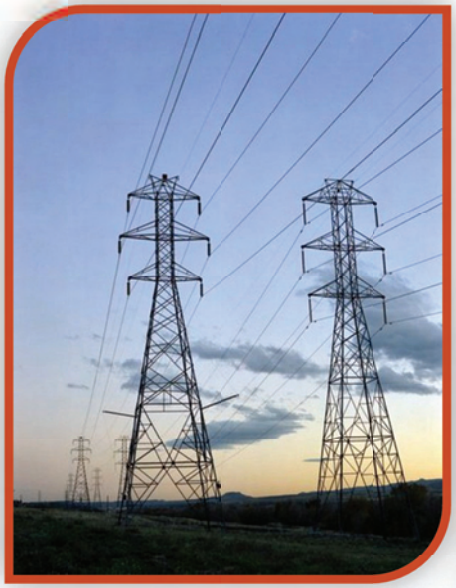
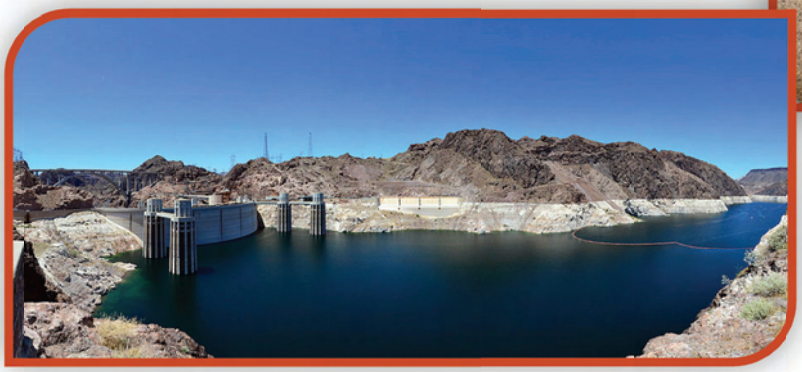
emPOWER ARIZONA





Executive Energy Assessment and Pathways 2014

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December 31, 2014

Dear Governor Janice K. Brewer:

In February of 2014, you signed an Executive Order to adopt Arizona's Master Energy Plan and establish a State Energy Advisory Board. The plan - titled *emPOWER Arizona: Executive Energy Assessment and Pathways* – was a collaborative effort completed by Executive Order in 2013 by the Governor's Office of Energy Policy (GOEP), Arizona Commerce Authority, Arizona Legislature, Arizona Corporation Commission and leading industry partners. Arizona's last energy plan was written in 1990.

As a result, executive level goals were identified to: increase solar development; educate Arizona's next generation of energy professionals on two levels: first, through energy education in high schools, and second through apprenticeship and job-training programs; reduce energy consumption; and establish an energy advisory board to address energy issues on an ongoing basis.

This year, an unprecedented effort was made by the GOEP to work with state agencies to work toward common energy goals.

Using a state-developed interactive mapping website, the GOEP worked with the Arizona State Land Department to identify unleased State Trust Parcels for potential solar development. This was done to help streamline the permitting process in anticipation of California increasing its renewable energy portfolio. In addition, a number of meetings were held to discuss the future of utility-scale projects slated for Arizona and work began on drafting an *Arizona Specific Environmental Permitting Handbook* for renewable energy projects.

In a coordinated effort, the GOEP met with representatives from the Arizona Department of Education to raise awareness and highlight energy-related careers by showcasing the Arizona energy sector at the Annual Arizona Science & Engineering Fair. In conjunction with Arizona Ready, the state's education reform plan, first-time energy awards for "Outstanding Energy Educator; Outstanding Energy Student; Outstanding Energy Education Program"; and an "Excellence in Leadership" were presented to recognize successful energy education achievements at the high school level.

To increase energy awareness on a state level, the GOEP teamed up with Arizona Forward, a statewide non-profit advocating for a balance between environmental quality and economic development, to create the Governor's Award for Energy & Technology Innovation presented at their annual environmental excellence awards, held in partnership with Salt River Project.

To elevate workforce opportunities in the energy sector, meetings were held with the GOEP, the Governor's Office of Workforce Development; the Arizona Commerce Authority and the Arizona Department of Economic Security. A website has been created to link a number of websites all targeting energy-related job information, job training and apprenticeship programs.

For example, the Arizona Commerce Authority website features a sector partnership website which provides real-world solutions for rural utilities struggling to fill critical line worker positions. The Cochise Utilities Sector Partnership was formed with Cochise Community College and Arizona Workforce Connection to develop new courses and a certificate program to prepare local candidates, improve the talent pipeline and provide long-term jobs for the community.

In addition, the Arizona Department of Economic Security, as of July 1, 2014, will provide quarterly data on energy-related jobs. For example, 107 energy jobs were posted in the 3rd quarter of 2014 with 54 listed by energy-related companies and 53 by Arizona utilities. Salaries ranged from a utility customer service representative at $13.64 to a utility lead construction specialist at $32.62 hourly. This information will be used to gage on a quarterly basis the types of employment available in Arizona's energy sector.

The GOEP has worked on two levels to encourage energy efficiency in state buildings. First, we developed a State Energy Savings Performance and Financing Contract through partnerships with the Arizona Department of Administration (ADOA), the Arizona State Procurement Office (SPO) and the Arizona Attorney General Office's (AG) which will be used by ADOA to identify, design, implement and maintain energy-efficiency projects through energy performance contracting in state buildings.

Second, ADOA, SPO and the Arizona School Facilities Board (SFB) updated their prequalified list of Energy Savings Performance Contractors (ESCOs) from which state agencies and school districts will be able to procure. This removes the necessity of every governmental entity going through this pre-qualified step. Plus, selecting from a pre-qualified list provides assurance that projects will be successful and reduces the time needed to get a contract in place. As an added feature, the GOEP will provide technical assistance for these projects, as it is required that all project contracts on the pre-qualified list be reviewed by the GOEP before agreement.

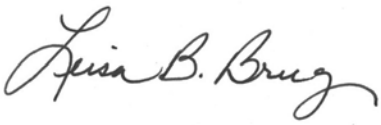
In addition, the GOEP is administering a pilot project with $1.1 million from the U.S. Department of Energy for energy upgrade projects in state buildings, and with energy savings, establishing a reinvestment fund for future project development. A series of on-going meetings have been held with representatives from the GOEP and the Arizona Department of Administration to help determine how to best implement this new program. A number of energy audits have been completed for this program with projects expected to be initiated and completed in 2015.

The State Energy Advisory Board met for the first time in October, 2014 to become familiar with and consider updates to *emPower Arizona: Executive Energy Assessment and Pathways*.

The 15-member board is comprised of the state's leading experts on energy and held discussions focused on the Environmental Protection Agency's proposed Clean Power Plan and its potential effect on Arizona's energy future. In their second meeting, held in December, the Board continued the dialogue on energy issues facing Arizona and strategies on how they can best serve the next administration in 2015.

Thanks to your vision and leadership, you have set the groundwork to position Arizona as an energy leader, working across the board - on all energy levels - to help secure a reliable and affordable energy future. It is with a deep sense of pride that I submit to you, the first back-to-back update of key energy information and statistics in Arizona history.

Sincerely,



Leisa B. Brug, Chairperson, State Energy Advisory Board
Energy Policy Advisor to Governor Janice K. Brewer/
Director, Arizona Governor's Office of Energy Policy

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EXECUTIVE SUMMARY

Because energy production, generation, transmission, and conservation are vital to Arizona's future, Governor Janice K. Brewer formed a Master Energy Plan Task Force in 2013. Arizona's last energy plan was written in 1990 and an updated assessment was much needed to lead the state towards a strong and sustainable energy future.

The 40 members of the Governor's task force served on four subcommittees: Transportation, Fuels, and Infrastructure Planning; Business, Regulation, and Workforce; Environment, Natural Resources, and Land Use; and Technology Development.

They met monthly to provide and consider information about the current status, key challenges and 10-year outlook for each subcommittee's specialty area. After the information was compiled and approved, the Governor's Office of Energy Policy convened statewide public meetings to encourage contributions from all stakeholders and further solicited experts to ensure the report was comprehensive and inclusive.

The public meetings highlighted the importance of an energy blueprint for Arizona's economy, job creation, and environment each of which rely heavily on Arizona's human and energy resources.

As a result, executive level goals were identified to: increase solar development; educate Arizona's next generation of energy professionals on two levels: first, through energy education in high schools, and second through apprenticeship and job-training programs; reduce energy consumption; and establish an energy advisory board to address energy issues on an ongoing basis.

Incorporating the considerable input provided to her, Governor Brewer created *emPOWER Arizona: Executive Energy Assessment and Pathways*, the guide that will help leaders make informed energy decisions to ensure Arizona has affordable and reliable energy resources.

Arizona has a diverse mix of electric power generation that uses a combination of conventional and renewable resources. Further, energy development has a strong impact on Arizona's economy, both directly by utilities and indirectly by every sector which uses energy.

It takes power to mine copper, turn on lights in classrooms, drive to work, turn on ovens for the midday lunch rush and keep people comfortable in their homes.

Because energy reaches deep into the economy, it is inextricably tied to job creation. Not only are Arizona's utilities among its largest employers, they also produce a commodity that affects the other employers they serve.

Reliable energy connections are essential for large employers considering relocating to Arizona or expanding existent operations. Also, the cost of energy and what that will mean for a large and small employers' bottom line has substantial implications in any relocation or expansion decision.

While it is important to focus on the economic impacts of energy and how they affect Arizona's residents, it is also important to consider the environmental results. Many more generations of Arizonans will follow ours, and it is up to all of us to make certain that the Grand Canyon State of the future is as breathtaking as it is today.

This Executive Summary and *emPOWER Arizona* is an unprecedented state effort that consolidates under common goals eight state agencies' directives toward energy workforce and development, education and outreach, and the establishment of a permanent platform for ongoing energy discussions that ensure Arizona will never again lack a strong energy resource guide.

GOALS

This document is the culmination of a yearlong stakeholder-driven process that has identified best practices, areas of improvement and future action items in the Arizona energy sector. With the outcomes of this process in mind, in addition to the executive-level goals outlined in the Executive Summary, Governor Brewer has created *emPOWER Arizona*, an energy resource guide that seeks to: identify current status in the Arizona energy portfolio, education, and workforce development; identify challenges and areas of concern such as federal regulations affecting energy pricing and the water-energy nexus; and create a 10-year outlook regarding the Arizona energy ecosystem.

Identifying and addressing the challenges expressed through stakeholder input is of the utmost importance to realize the state's energy potential. The Governor's Office will place high priority on the following executive-level goals to address those challenges:

1. Increasing Solar Energy Development through Best Practices and Leading by Example

Governor Brewer's commitment to make Arizona the "Solar Capital of the World" has become well-known across the nation. While many states have similar aspirations, through Governor Brewer's leadership, Arizona is now second in the nation in solar installations and has, in 2010, enacted a solar tax incentive program that has translated to more than $1.2 billion of investment in the Arizona economy. To sustain this momentum, in 2011 Governor Brewer established the Solar Energy Advisory Task Force to retain and enhance Arizona's solar energy industry. The task force established a residential and commercial permitting best-practices program to help drive down the soft costs related to solar installations. During the establishment of the best practices for residential and commercial, industry leaders in the

utility-scale solar development sphere expressed concerns related to permits for large utility-scale projects.

To address these concerns, in 2013 the Governor's Solar Energy Task Force created the Utility-Scale Permitting Reform Subcommittee.

Destination:

Eliminate redundancy in multijurisdictional approval processes for utility-scale projects in Arizona and enable local jurisdictions to adapt their ordinances, codes and requirements to better fit utility-scale solar projects.

In addition, Arizona must lead by example in utility-scale solar development. Therefore, the Governor has expanded the partnership between the GOEP and the Arizona State Land Department (ASLD). The GOEP and ASLD, using a state-developed interactive mapping website called the Arizona Solar Energy Viewer, will identify trust lands near an electrical substation and areas where solar might be economically appropriate and suitable relative to the surrounding land uses. They will work with the local jurisdictions to speed processing and permitting of utility-scale solar projects.

Pathway:

Identify utility-scale permitting model ordinances and best practices across jurisdictions and promote Renewable Energy Incentive Districts (REIDs). For example, Pima County created a solar-power incentive district identifying specific regions of the county suitable for utility scale solar arrays, and offers options to encourage their use. The Governor's Office of Energy Policy (GOEP) will partner with Authorities Having Jurisdiction (AHJ) to create the best practices database, promote those practices state wide and work with those jurisdictions on establishing REIDs.

Pathway:

Initiate the Arizona Land Energy Assessment Dispensation (AZ-LEAD) to identify, form partnerships and lead Arizona in utility-scale solar development.

2. Educating Our Next Generation of Energy Professionals

Because energy is a critical economic driver, energy literacy such as STEM education (Science, Technology, Engineering, and Mathematics) and sector-based training must be integral parts of our educational system if Arizona is to be competitive in the 21st century economy. Students are future stewards of good energy-use policies and practices. A relevant educational experience through practical scientific applications within the field of energy will create a

connection between energy and education policy and lead to more relevance in science and math, a stronger energy workforce, and smarter energy consumers.

Destination:

Arizona has a vibrant informal education community committed to energy education, but too often these efforts and partnerships go unnoticed. Tremendous opportunity exists to expand the visibility, and the effectiveness, of these partnerships that support Arizona's students.

Pathway:

The Governor is establishing an energy awards program in conjunction with Arizona Ready that will include: Best Informal Program; Best School (district and charter); Best Teacher Preparation Program; Best Teacher; Best Project Awards. GOEP will administer the program; the annual awards will bring needed visibility to organizations and people excelling in energy education.

Pathway:

Raise awareness and highlight energy-related careers by showcasing the Arizona energy sector at the Annual AZ Science & Engineering Fair and every third year at the Intel International Science and Engineering Fair. GOEP will facilitate the distribution and marketing of career development information at these events in order to bring attention to careers in energy, specifically to job seekers but to the general public as well.

Pathway:

As part of every Arizona high school student's requirement to complete an Education Career Action Plan (ECAP), each student has private access to the Arizona Career Information System (AZCIS) or similar system. Collaboration between the Arizona Department of Education and the GOEP will ensure energy careers are supported in AZCIS.

3. Making Arizona a Leader in Energy-Sector Workforce Development

Leading indicators show that Arizona's population will continue to grow well into the future as will its energy needs. Arizona, like the rest of the nation, has an aging energy sector workforce; however, the state has the opportunity to be a leader in educating the next generation of energy employees, with on-the-job training such as apprenticing, energy-specific workforce training and succession planning by power plants and utilities. Arizona local utilities are often a key source of jobs and long-term employment; and in rural Arizona, they are the economic drivers that communities depend upon. As a response to workforce concerns, the Governor is establishing a partnership between the Governor's Office of Workforce Development (GOWD), GOEP, and the Arizona Commerce Authority (ACA) to improve energy-related job training and marketability of Arizona's energy workforce.

Destination:

A well-trained, globally competitive energy-related workforce will drive economic competitiveness. We will accomplish this by attracting; retaining and expanding companies in the energy sector and build on existing education and energy-specific training programs throughout the state.

Pathway:

Identify energy-specific and related education and training programs and create a “one-stop shop” database for Arizonans looking to enter the field with support from GOWD and GOEP and housed within the Arizona Department of Economic Security (DES).

Pathway:

Create the Arizona Center for Energy Education and Training (ACEET) charged with collaborating with the community colleges’ curriculum development in energy-related programs. The GOWD, GOEP and ACA together will act as a conduit for the voice of education and business in the energy industry by coordinating and analyzing the information from all statewide energy-sector education and training institutions into a regular report for public distribution.

4. Fostering Statewide Coordination to Reduce Energy Consumption

Arizona has a long history of actively and effectively reducing electricity use through energy-efficiency technologies. From homes to businesses to large electricity users, energy efficiency is the foundation of clean and cost-effective energy. The State will advance programs to address energy-saving financing mechanisms. It will also recognize exemplary entities to foster growth in energy efficiency and technology. For example, Mary E. Dill Elementary School, of the Altar Valley Elementary School District in Tucson, reduced their annual utility costs by 31 percent by doing a lighting upgrade and installing new control systems for lighting and heating, ventilation and air conditioning (HVAC) units.

Destination:

Increase access to capital for large energy users, including state agencies, to use energy-efficiency technologies to enhance the local economy as well as award entities for energy-saving projects.

Pathway:

Develop a State Energy Savings Performance and Financing Contract through partnerships with the Arizona Department of Administration (ADOA), the Arizona State Procurement Office (SPO) and the Arizona Attorney General Office's (AG) which will be used by ADOA to identify, design, implement and maintain energy-efficiency projects through energy performance contracting in state buildings.

Pathway:

ADOA, SPO and the Arizona School Facilities Board (SFB) will develop an updated prequalified list of Energy Savings Performance Contractors (ESCOs) from which state agencies and school districts will be able to procure. Require that all project contracts on the pre-qualified list are reviewed by the GOEP before agreement.

Pathway:

Establish an annual statewide Energy Efficiency recognition program for municipalities, businesses and nonprofits administered by the GOEP.

5. Establishing an Energy Advisory Board

The Governor will establish a permanent State Energy Advisory Board, administered by the GOEP Director, to ensure a timely, ongoing discussion with experts about energy status, outlooks, technology developments and issues. This group will be staffed by the GOEP and be responsible for updating *emPOWER Arizona* at least every five years. This group will convene biannually at the Executive Tower of the State Capitol. Group members will be directly appointed and serve at the pleasure of the Governor.

Destination:

Establish a board representing the broad energy landscape of Arizona that will provide input, initiate discussions and create the basis for updates to *emPOWER Arizona*. Before each biannual meeting, board members will be presented with the Arizona Energy Scenario Plan to review and provide an update on the Arizona energy sector.

Pathway:

The Arizona Energy Advisory Board will be established through an Executive Order.

1. ENERGY OVERVIEW, CONSUMPTION AND 10-YEAR OUTLOOK

According to the U.S. Census Bureau, Arizona is among 10 of the nation's fastest growing states. Known for its mild winters and hot summers, Arizona's energy demand is contingent on its growing population, arid climate, and extreme summer weather. The state's widely varied five climate zones range from cold mountainous regions to cool plateau highlands to high-altitude deserts to mid-altitude deserts to low-altitude deserts.[1] The densest population centers (Maricopa and Pima counties) are in the mid- and low-altitude desert regions. Smaller communities located in the northern regions have moderate weather for three seasons a year and significant snowfalls.

In 2012, the U.S. Energy Information Administration (EIA) ranked Arizona as the 15th most populous state and 43rd in per capita energy demand or consumption.

OVERVIEW

According to EIA, there are 60 generating facilities in Arizona. The Palo Verde Nuclear Generating Station is the largest at about 3,900 megawatts (MW); it is the nation's largest nuclear plant and has the second-highest rated capacity of any power plant in the United States. Twenty-nine natural gas power plants, six coal power plants, 12 hydroelectric power plants and one surface coal mine contribute to Arizona's extensive power generation, so much so that the state exports large amounts of electricity to neighboring states.

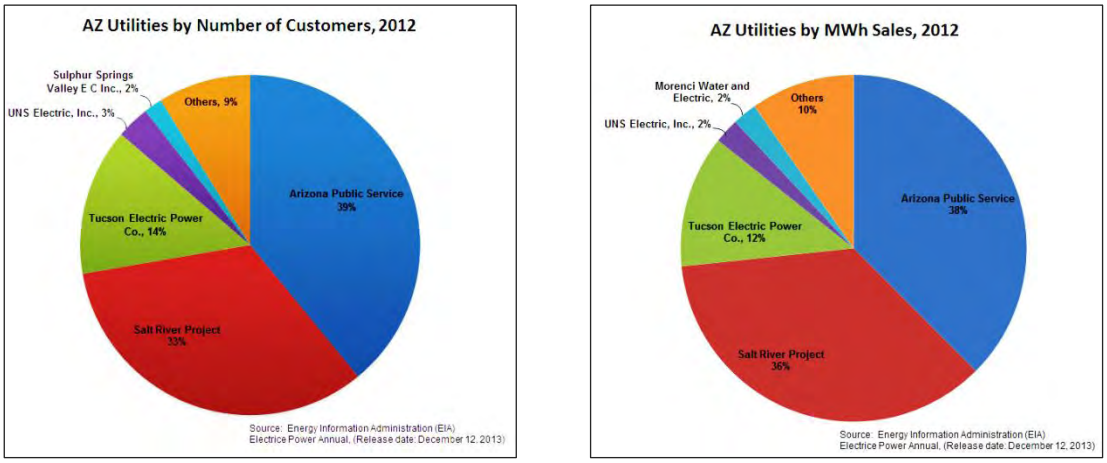


Figure 1

There are many private utility companies, electric cooperatives, and municipalities that provide electric service to Arizonans. However, as Figure 1 illustrates, the majority of Arizonans are served by only a small number of these. The largest providers in terms of both customers served and in sales are (in order) Arizona Public Service (APS), Salt River Project (SRP), Tucson Electric Power (TEP) and Unisource Energy Services.

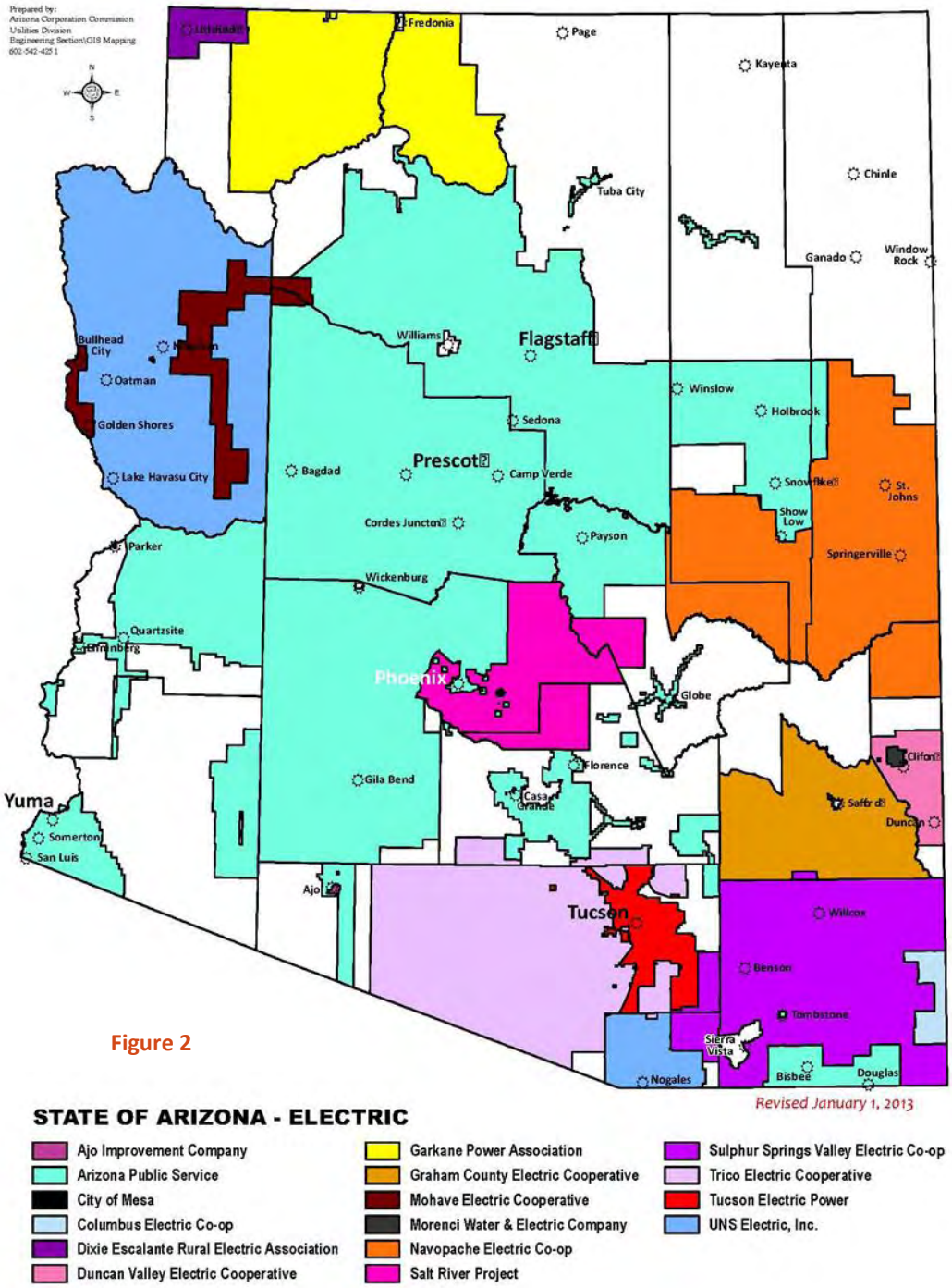


Figure 2

Figure 2 shows electric utility companies and service areas in Arizona.

(Note: Tucson Electric Power and Unisource Energy Services are subsidiaries of UNS Energy Corporation, which was acquired by Fortis, Inc., Canada's largest investor-owned gas and electric distribution utility in 2014.)

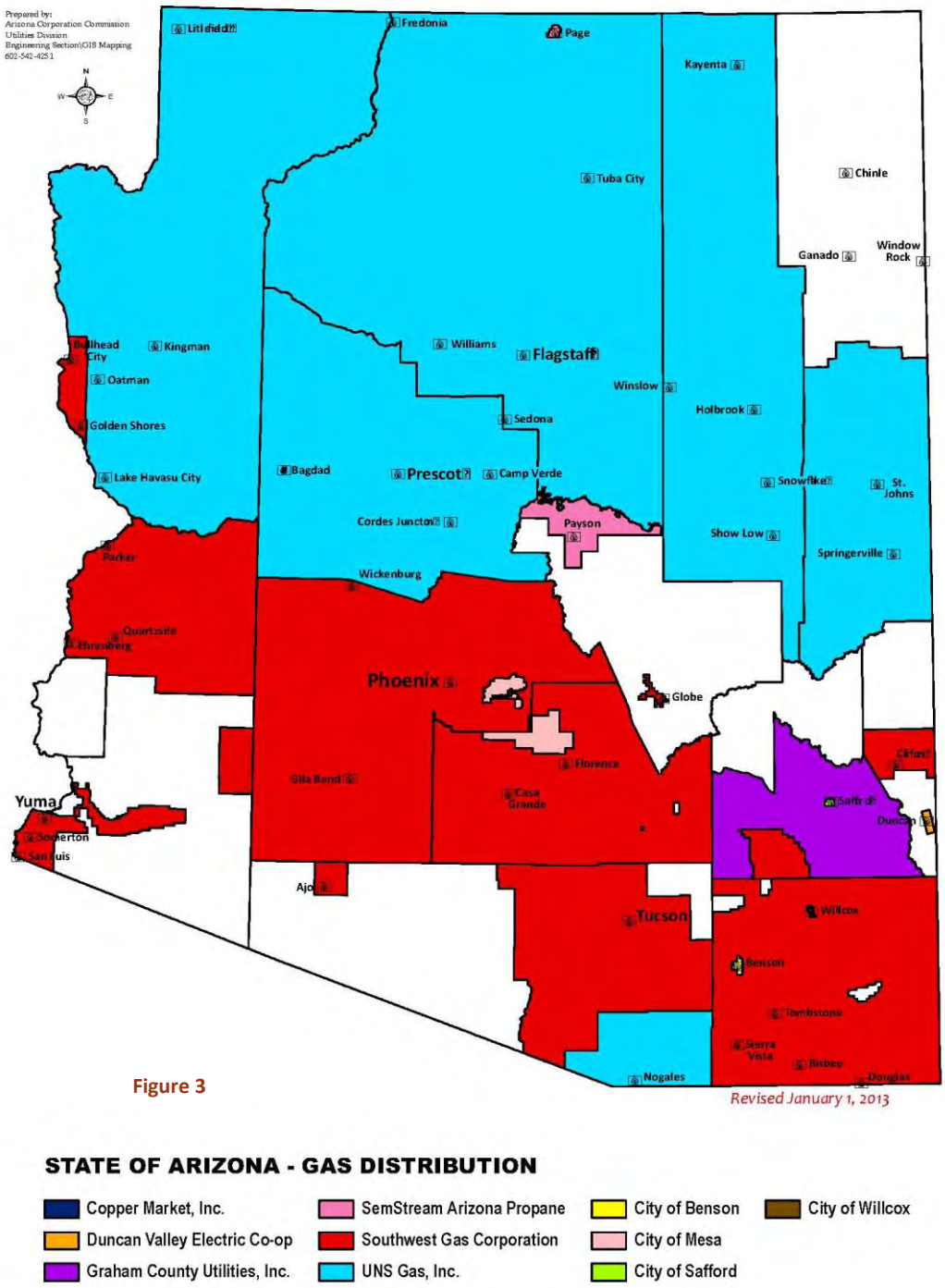


Figure 3

In addition, as shown in Figure 3, there are utility companies that provide natural gas distribution in Arizona, primarily Southwest Gas Corporation which serves areas in central, western and southern Arizona, and UNS Gas which serves areas in northern Arizona and Santa Cruz County, located in southern Arizona.

CONSUMPTION

While local utilities provide electricity and natural gas for Arizona homes, communities and businesses, Arizonans use petroleum, primarily for transportation, more than any other portion of energy consumption. As Figure 4 illustrates, of Arizona's energy-usage portfolio: petroleum is highest at 28.6 percent; followed by coal-generated electricity at 24.6 percent.

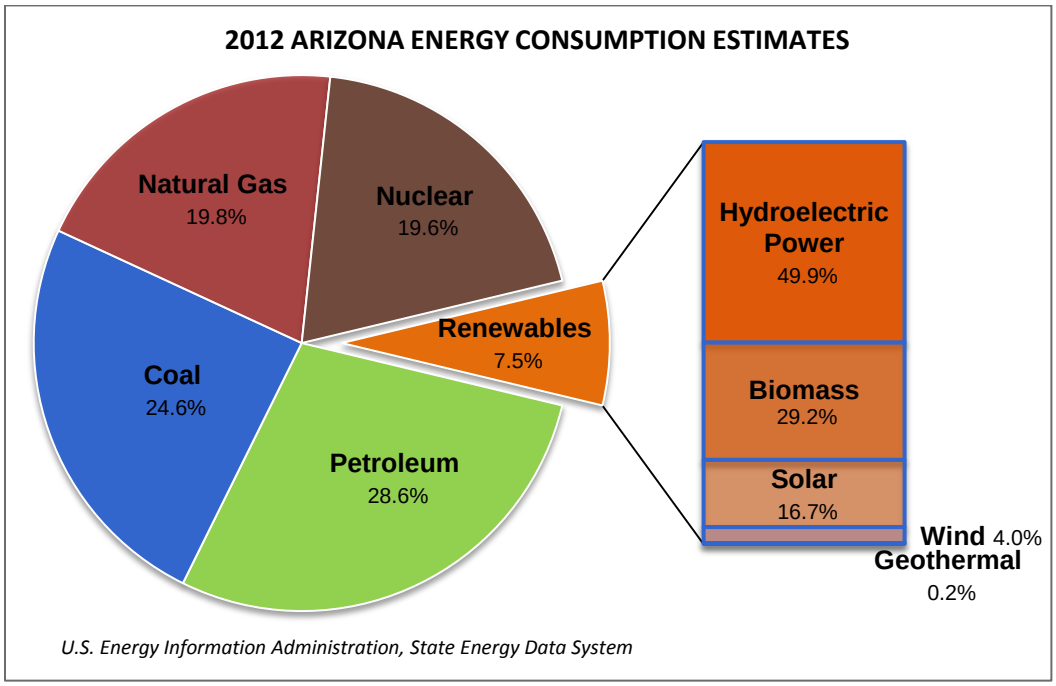


Figure 4

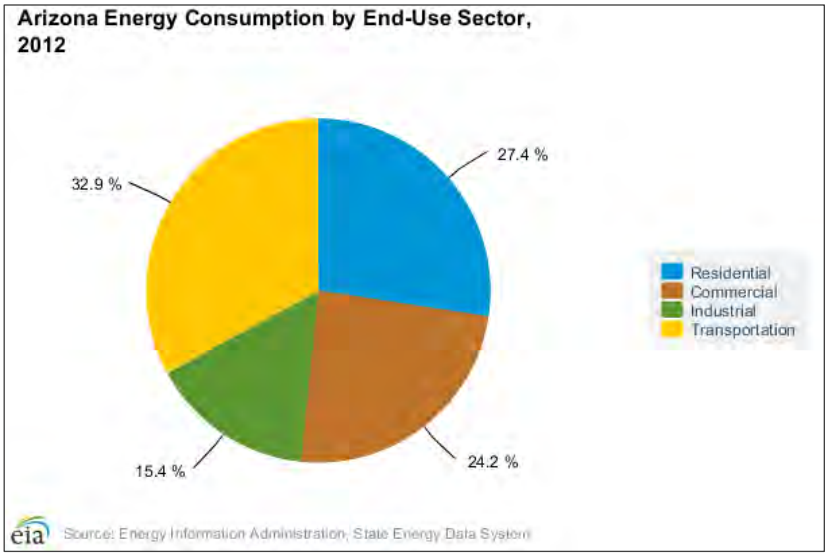


Figure 5

Figure 5 shows the breakdown of Arizona's energy consumption by end-use sector: Residential, Commercial (consists of service-providing facilities and equipment of businesses), Industrial (consists of all facilities and equipment used for producing, processing, or assembling goods) and Transportation.

Transportation still takes up most of Arizona's energy portfolio at 32.9 percent, up from 32.8 percent from 2011.

Since 1960, primary energy-resource consumption within Arizona has steadily increased. As shown in Figure 6, the predominant energy-consuming sectors in the state's economy are electricity and transportation. The increase in energy consumption from 1990 to 2010 is attributable to Arizona's unprecedented population growth of 73.9 percent during that 20-year time span.

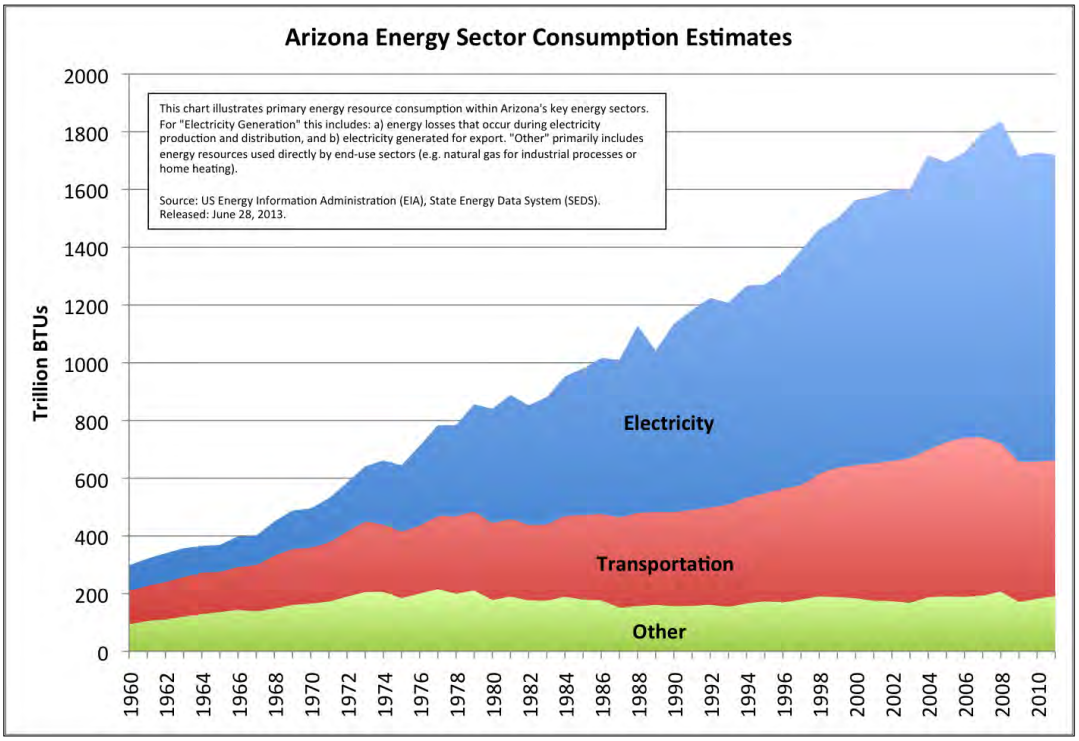


Figure 6

Figure 7 shows the majority of average household energy consumption in Arizona is the use of appliances, electronics, pool pumps, etc., at 36 percent.

According to EIA, 25 percent of the energy consumed in Arizona homes is for air conditioning. In addition over one-half of Arizona households rely on electricity as their primary source for home heating. This consumption is more than four times the national average of 6 percent.

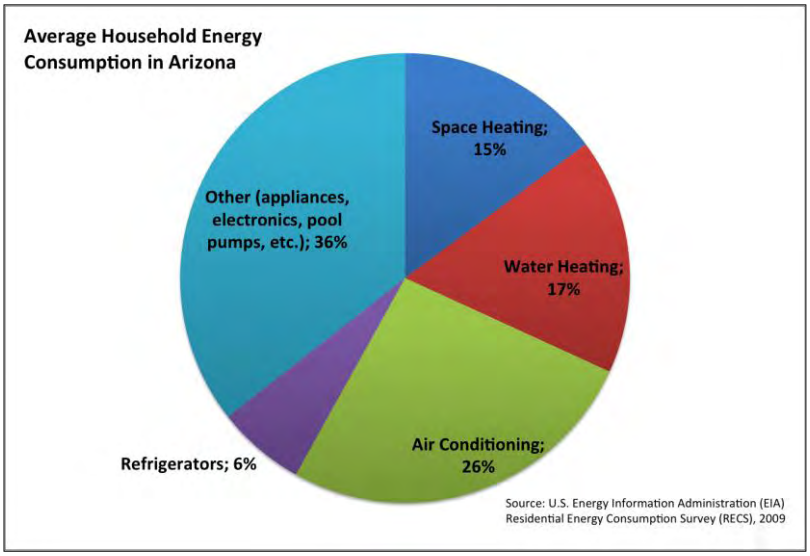


Figure 7

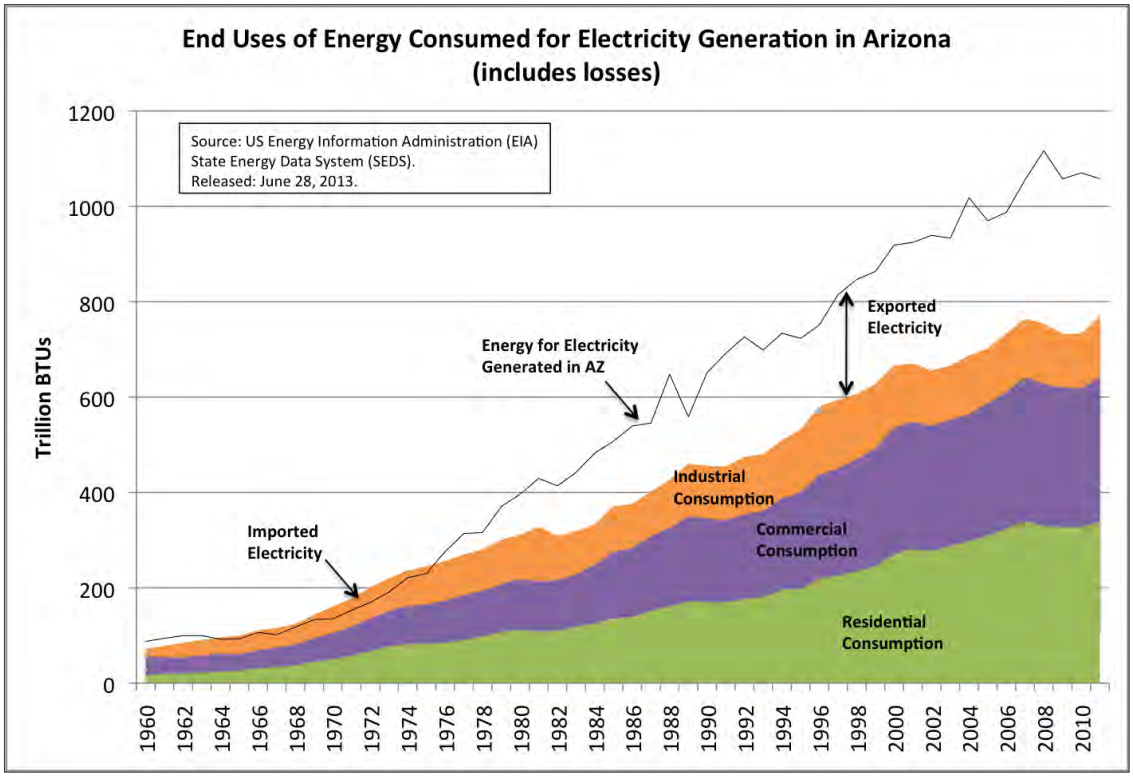


Figure 8

Figure 8 shows that since 1960 most of the energy resources needed for electricity generation have been driven by demand in Arizona's residential and commercial sectors. Additionally, a significant portion of electricity generated in the state is then exported to other states.

Energy Production

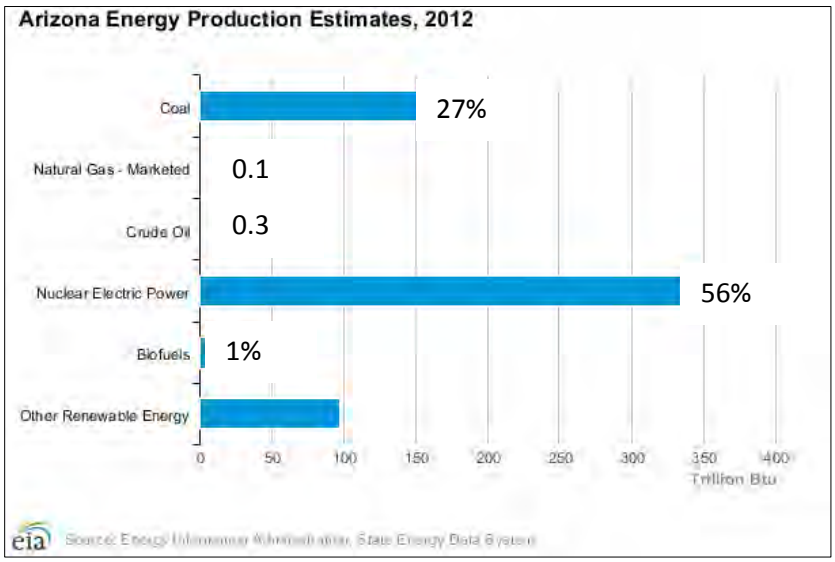


Figure 9

In 2012, Arizona ranked 27th in terms of total energy production, according to EIA, no change from 2011.

Figure 9 shows that nuclear produced the most at 56 percent, up 3 percent from 2011.

This is the production of energy generating resources. For example Arizona generates a third of its power from natural gas, however, because there are minimal native natural gas resources in Arizona the state's energy production from natural gas is also minimal.

Arizona's only operating coal mine, Kayenta, on the Navajo and Hopi reservations, supplies the seven to eight million tons burned annually by the Navajo Generating Station's three 750-MW units.

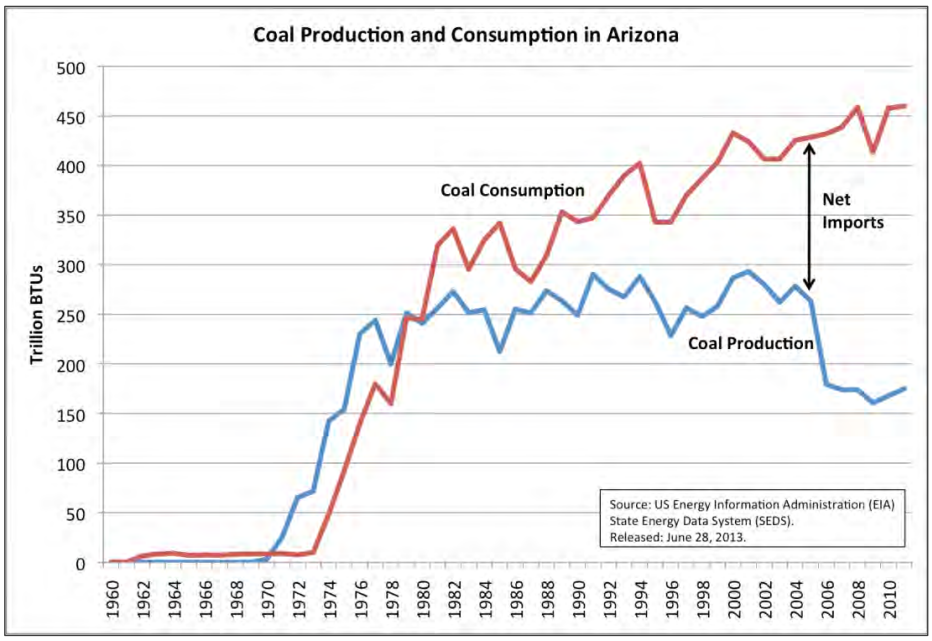


Figure 10

Figure 10 shows that a significant portion of the resources used for electricity generation in Arizona is imported from outside the state. While Arizona does have significant coal production, it is still a net importer of coal resources. (Note: The sharp decline in coal production was the result of the closure of the Black Mesa Mine, which produced about 5 million tons of coal annually.[2])

Figure 11 shows that Arizona has virtually no natural gas production and thus relies on out-of-state supplies.

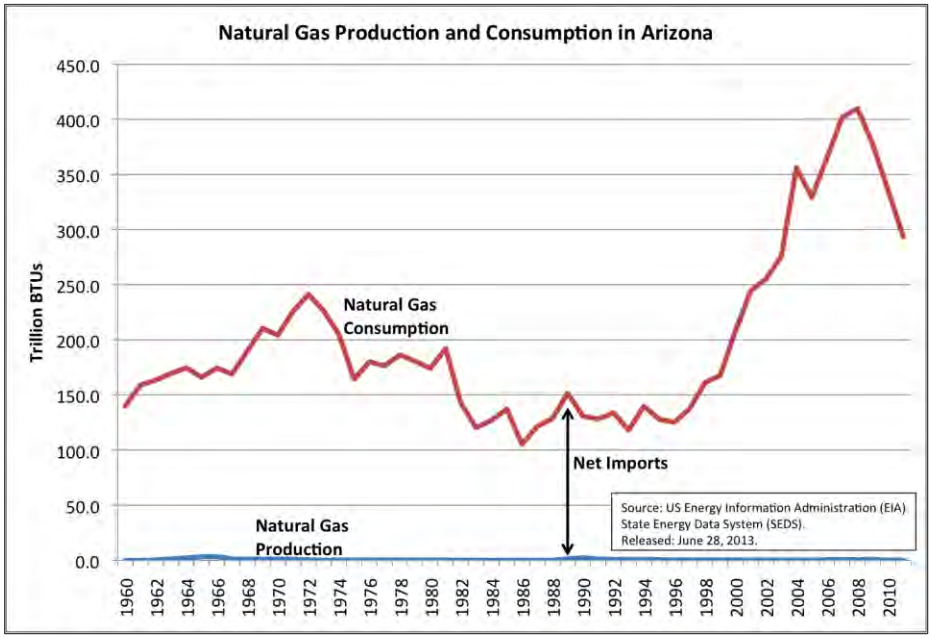


Figure 11

Transportation Sector

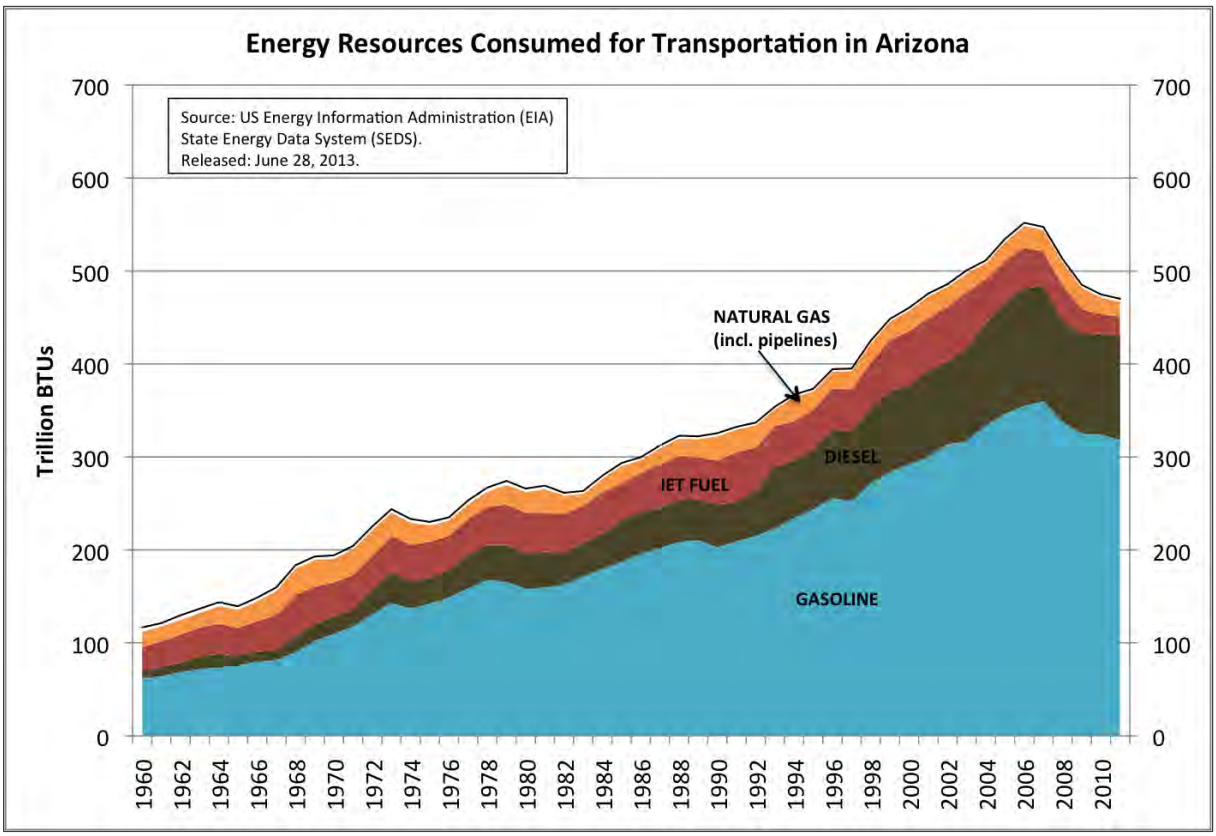


Figure 12

As shown in Figure 12, transportation is the largest energy source used in the state. Arizona's transportation sector is fueled almost exclusively by petroleum products. Since 1960, gasoline comprises the largest portion of transportation energy, reflecting the prominence of the light-duty fleet of cars and trucks. However, a significant fraction of diesel and jet fuel shows the importance of heavy-duty trucks and aviation.

Figure 13 shows that like electricity resources, Arizona has virtually no petroleum production and relies on imports of finished petroleum products. While building a refinery in Arizona has been discussed, the project has never come to fruition.

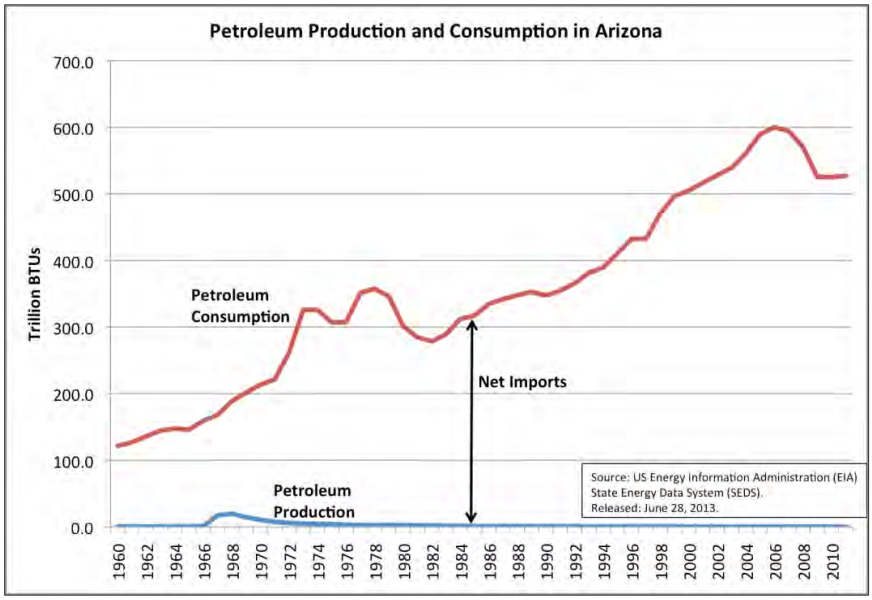


Figure 13

Estimated Energy Expenditures

According to EIA and shown in Figure 14, in 2012 total end-use energy expenditures for Arizona were estimated at $22.7 billion. Petroleum led this category at an estimated $14.3 billion.

The residential average retail price* of electricity in 2012 was 11.29 cents per Kilowatthour (kWh); up from 11.08 cents per kWh in 2011. *(NOTE: *Table 8.)*

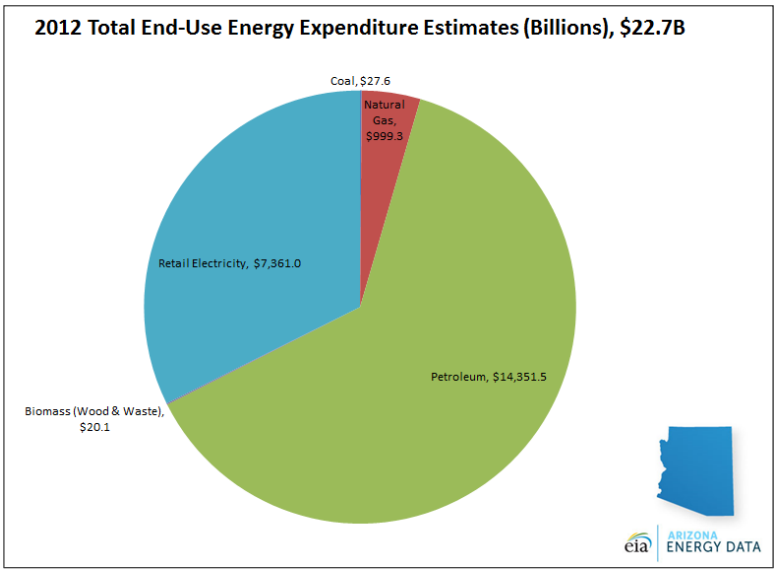


Figure 14

Challenges

With the majority of Arizona's population living in desert regions, meeting summer energy demand will continue to be an ongoing challenge and concern.

Over the years, Arizona utilities have consistently added new transmission facilities to address reliability and ensure that they can meet load-growth requirements. They have sufficient capacity to meet current demand through owned and contracted generation. However it remains to be seen how far these resources can carry the state into the future. Arizona is also home to the Palo Verde trading hub, one of the largest trading markets in the West. This is important because power can be purchased from different markets in Arizona.[3]

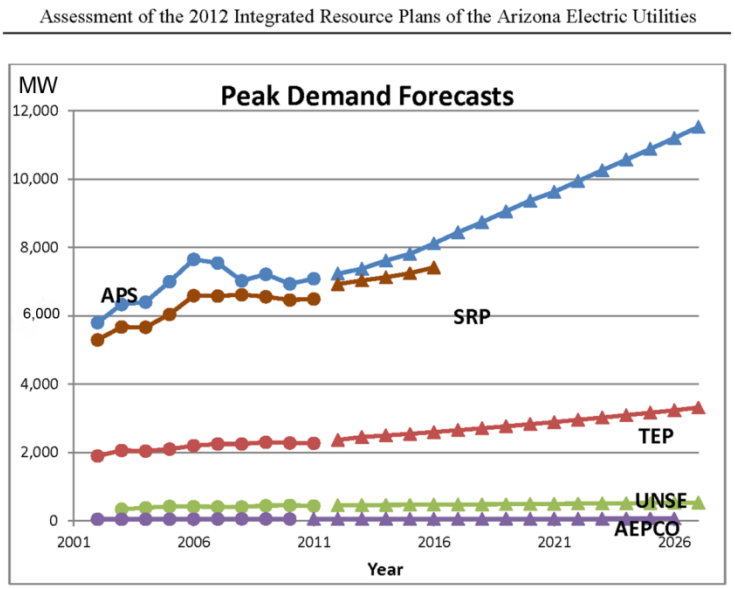


Figure 15
(Graph courtesy of Global Energy & Water Consulting, LLC and Evans Power Consulting, Inc.)

10-Year Outlook

Although Arizona experienced a strong population growth from 1990 to 2010, its current increase has slowed. In 2001, Arizona's population was 5.3 million increasing to 6.4 million in 2011, up 21 percent, according to the Arizona Department of Administration, Office of Employment and Population Statistics. Projections for Arizona's population are expected to continue to rise 20 percent from 6.5 million in 2013 to 7.8 million in 2023. As shown in Figure 15, utilities anticipate an increase of 15 to 20 percent in Arizona's peak load over the next 10 years.

Smart Grid Development

Smart grid generally refers to using computer-based remote control and automation technologies. According to U.S. Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability, these systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. They are beginning to be used on electricity networks, from the power plants to renewable energy generating facilities all the way to consumers of electricity in homes and businesses. They offer many benefits to utilities and consumers – mostly seen in big improvements in energy efficiency on the electricity grid and in the energy users' homes and offices.

Smart grid development has begun in Arizona and has the potential to improve reliability, resiliency, flexibility, and efficiency (both economic and energy) of the electric delivery system. Listed below are project summaries featured in the *Smart Grid Investment Grant Program Progress Report* published by DOE in July 2012.

Western Electricity Coordinating Council (WECC):
Western Interconnection Synchrophasor Program

The WECC and eight of its member transmission owners are deploying synchrophasor devices throughout the U.S. portion of the Western Interconnection, which Arizona is a part of. The project aims to improve electric system reliability and restoration procedures and prevent the spread of local outages to neighboring regions. The project could also improve the grid integration of renewable resources. Phasor measurement units, phasor data concentrators, communication systems, information technology infrastructure and advanced transmission software applications are being deployed. These systems increase grid operators' visibility of bulk-power system conditions in near-real time, enable earlier detection of problems that threaten grid stability or cause outages, and facilitate sharing of information with neighboring control areas. Having access to better system operating information allows WECC staff to improve power system models and analysis tools, thus improving the reliability and operating efficiency of the bulk-power system.

Salt River Project (SRP) Agricultural Improvement and Power District: Advanced Data Acquisition and Management Program

SRP Agricultural Improvement and Power District's Advanced Data Acquisition and Management Program involves the installation of smart meters and supporting communication infrastructure and the expansion of advanced electric service options for customers. Virtually all SRP customers are receiving new smart meters which monitor electric consumption and power quality. A two-way communication system relays customer electricity data from the distributed smart meters to the utility where upgraded software platforms analyze and present the data. SRP expects the smart meters to reduce meter-reading costs and field service visits, lower vehicle emissions, and enable development of advanced electric services for customers. These services include a web portal and expansion of existing time-of-use rates that empower the customer and enable a lower peak demand for SRP. Charging stations for plug-in electric vehicles and transformer metering are being monitored and evaluated.

Southwest Transmission Cooperative, Inc. (SWTC): Arizona Cooperative Grid Modernization Project

The Arizona Cooperative Grid Modernization Project upgrades electric infrastructure for three electric cooperatives in Arizona. SWTC is the primary recipient of the project. The project also includes two distribution system cooperatives, Mohave Electric Cooperative (MEC) and Sulphur Springs Valley Electric Cooperative (SSVEC), which receive transmission service from SWTC. SWTC is upgrading the communications infrastructure of its transmission network by installing optical ground wire cables between several substations. The project also includes installing microprocessor-based protective relays and equipment monitors. MEC is replacing thousands of existing meters in its service territory with smart meters and is expanding the communications network and power-line-carrier-based meter communications system. SSVEC is implementing advanced metering infrastructure (AMI) and distribution automation, as well as expanding its existing fiber optic communication infrastructure and upgrading its monitoring software as well.

Navajo Tribal Utility Authority (NTUA): Smart Grid Project

NTUA's advanced metering infrastructure (AMI) project is deploying 28,000 residential smart meters and supporting communications and information technologies. The project provides automated meter reading, improved outage detection and response, power-quality monitoring, and tamper-detection capabilities. The communications system relays customer electricity data to NTUA, where the new meter data management system helps NTUA leverage the data to better manage peak demand, which reduces system wide capacity needs, electrical losses, and operations and maintenance costs.

Arizona Public Service (APS):
Smart Grid Projects

Although not part of the DOE report, APS was recognized by Greentech Media in 2012, as one of their Top Ten Utility Smart Grid Deployments in North America. APS's smart grid initiatives, and more specifically its distribution infrastructure upgrades, have made it one of the most reliable utilities in the United States. The utility's best-in-class performance has largely been a result of its award-winning transformer oil analysis and notification (TOAN) program, which has allowed transformer health to be monitored remotely in near real-time, helping both to prevent faults and quickly restore interruptions.

APS has also implemented self-isolating and self-healing technologies on two of its main distribution lines in Flagstaff. Additionally, the utility has integrated more than 200 MW of consumer-owned photovoltaic systems into its distribution grid – one of the largest portfolios of photovoltaic (PV) capacity in North America. The company's Flagstaff microgrid project is incorporating an additional 1.5 MW of PV capacity, solar hot water heaters and micro-wind turbines, as well as a 1.5 MW hour (MWh) lithium-ion battery storage system designed to complement the utilities' 500 kilowatt (kW) Doney Park PV farm.

ARIZONA'S REGULATORY FRAMEWORK

Arizona Corporation Commission (ACC)

The ACC is the sole regulatory body created by the Arizona Constitution to

> "prescribe…just and reasonable rates and charges to be made and collected, by public service corporations within the State for service rendered therein, and make reasonable rules, regulations and orders, by which such corporations shall be governed in the transaction of business within the State…"
>
> Ariz. Const. art. XV, §3.

In 1994, the ACC began restructuring the electric generation industry in Arizona from a system of regulated utilities to a competitive market, but in 2004 the Arizona Appellate Court decided portions of this restructuring were unconstitutional.[4] Furthermore, Arizona witnessed California's electricity crisis in which decreased supply and manipulation of the energy markets created huge price spikes and rolling blackouts. Therefore, the ACC withdrew from pursuing these actions. In 2013, the ACC opened a docket (E-00000W-13-0135) to invite all interested parties to file comments on whether it is in the public interest to implement electric retail competition in Arizona. However, because there had been no changes since the 2004 Court of Appeals decision and the constitutional impediments remained, the Commission voted in a September 2013 Staff Open Meeting to close this docket and open a new docket. The new docket is a Commission inquiry into how innovation and technological developments may impact current utility business models (E-00000J-13-0375).

The ACC regulates investor-owned utilities and the state's electric co-ops to set retail rates for electricity and gas, to determine renewable energy and energy efficiency requirements for utilities, and to rule on applications regarding the siting of new power plants and transmission lines. The ACC's regulatory jurisdiction covers the following electric utilities (among others):

Electric Utilities Overseen by Arizona Corporation Commission
Ajo Improvement Company
Arizona Electric Power Cooperative, Inc.
Arizona Public Service Company
Columbus Electric Cooperative, Inc.
Dixie-Escalante Rural Electric Association, Inc.
Duncan Valley Electric Cooperative, Inc.
Garkane Energy Cooperative, Inc.
Graham County Electric Cooperative, Inc.
Mohave Electric Cooperative, Inc.
Navopache Electric Cooperative, Inc.
Sulphur Springs Valley Electric Cooperative, Inc.
The Morenci Water and Electric Company
Trico Electric Cooperative, Inc.
Tucson Electric Power Company
UNS Electric, Inc.

The ACC's jurisdiction encompasses not only electric utilities, but also gas utilities. The regulated gas utilities are (among others):

Gas Utilities Overseen by Arizona Corporation Commission
Copper Market, Inc.
Duncan Valley Electric Cooperative's Gas Division
Graham County Utilities, Inc. (Gas Division)
SemStream Arizona Propane, L.L.C. (Alliant Gas, L.L.C.)
Southwest Gas Corporation
UNS Gas, Inc.

Governor, State Legislature and Local Governance

The governor, state legislature and local governments also play a role in regulating the state's energy industry by developing policies, setting rates, and enacting legislation and ordinances. This governance can be set through the state legislature, municipalities, or districts and may take the form of state statutes, district regulations, and local ordinances.

In August of 2014, 18 public and Tribal Arizona utilities entered into an agreement to operate the "Southwest Public Power Agency (SPPA)." This new joint action agency – authorized by

state law – will manage through a formal pool all or most of its members' power resources and facilitate the supply of additional energy needed to meet their customers' loads. The initial pool members include irrigation and electrical districts, municipal electric utilities and tribal utilities.

SPPA was formed to give these publicly *owned, not-for*-profit electric utilities a mechanism to jointly manage and dispatch their power resources and pursue affordable power supply opportunities for the customers they serve.

The following is a list of utilities governed by these jurisdictions:

Utilities Overseen by the Governor, Legislature and Local Governance
Aguila Irrigation District
Buckeye Water C&D District
City of Fredonia
City of Mesa
City of Safford
City of Williams
Electrical District No.5 Maricopa County
Electrical District No.2 Pinal County
Electrical District No.3 Pinal County
Electrical District No.4 Pinal County
Electrical District No.5 Pinal County
Electrical District No.6 Pinal County
Electrical District No.7 Maricopa County
Electrical District No.8 Maricopa County
Harquahala Valley Power District
Hohokam Irrigation and Drain District
Maricopa County M W C District No.1
McMullen Valley Water C&D District
Ocotillo Water Conservation District
Page Electric Utility
Roosevelt Irrigation District
Salt River Project
Tonopah Irrigation District
Town of Thatcher
Town of Wickenburg
Wellton-Mohawk Irrigation & Drain District

This governance structure also applies to the following natural gas utilities:

Gas Utilities Overseen by the Governor, Legislature and Local Governance
City of Willcox
City of Benson
City of Mesa
City of Safford

Tribal Governance

Tribal utilities are governed in a variety of ways. Many of the tribal areas have connections with the previously mentioned utilities. That said, there are two separate governances within the tribal nations. One is the governance of the utility by the tribal nation and, in some cases, the utility is created and operated as a tribal authority. The other is governance of the tribal utility by the Bureau of Indian Affairs (BIA). Below are tables specific to the known tribal utilities (gas and electric) governance structures:

Electric Utilities Overseen by Tribal Governments
Tohono O'odham Tribal Utility Authority
Navajo Tribal Utility Authority
Gila River Indian Community Utility Authority
Aha Macav Power Service
Ak-Chin Energy Services

Electric Utilities Overseen by the Bureau of Indian Affairs
Colorado River Agency Electric Systems
San Carlos Irrigation Project

Gas Utilities Overseen by Tribal Governments
Tohono O'odham Tribal Utility Authority
Navajo Tribal Utility Authority
Aha Macav Power Service

Federal Governance

The planning, development and operation of Arizona's energy infrastructure is regulated not only by state and local entities but also by geographic and federal entities and organizations. These entities and organizations include the Federal Energy Regulatory Commission (FERC), the North American Electric Reliability Corporation (NERC), the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), Western Electricity Coordinating Council (WECC), and WestConnect.

Federal Energy Regulatory Commission (FERC)

FERC is an independent agency that regulates the interstate transmission of electricity, natural gas and oil and licenses hydropower projects. The Energy Policy Act of 2005 gave FERC additional responsibilities including:

- Regulating the transmission and wholesale sales of electricity in interstate commerce.
- Reviewing certain mergers and acquisitions and corporate transactions by electricity companies.
- Regulating the transmission and sale of natural gas for resale in interstate commerce.
- Regulating the transportation of oil by pipeline in interstate commerce.
- Approving the siting and abandonment of interstate natural gas pipelines and storage facilities.
- Protecting the reliability of the high-voltage interstate transmission system through mandatory reliability standards.
- Monitoring and investigating energy markets.

North American Electric Reliability Corporation (NERC)

NERC is a not-for-profit entity whose mission is to ensure the reliability of the Bulk-Power System in North America. NERC develops and enforces reliability standards; annually assesses seasonal and long-term reliability; monitors the bulk-power system through system awareness; and educates, trains and certifies industry personnel.

Environmental Protection Agency (EPA)

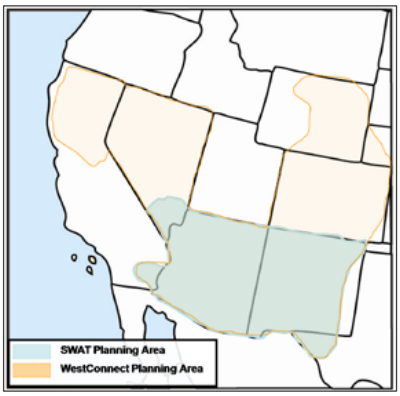
The EPA regulates the energy sector in Arizona through clean air requirements, energy extraction regulation, energy waste disposal requirements and water regulations related to discharge. The agency, through these regulations, plays a key role in energy production and development within Arizona relative to environmental laws which regulate the energy industry. The Arizona Department of Environmental Quality implements these programs for the EPA in the state.

Nuclear Regulatory Commission (NRC)

Arizona is home to the Palo Verde Nuclear Generating Station (PVNGS); this plant and its operations come under the purview of the NRC. The NRC's regulatory activities in Arizona are focused on reactor safety oversight, reactor license renewal, materials safety oversight, materials licensing, and waste management. If there were to be an expansion at Palo Verde or a new plant to be built, the NRC would be the licensor and would evaluate the application.

Western Electricity Coordinating Council (WECC)

WECC is the regional entity in the western interconnection responsible for coordinating and promoting the bulk electric system reliability. In addition, WECC provides an environment for coordinating the operating and planning activities of its members including utilities in Arizona.



WestConnect and Southwest Area Transmission

WestConnect is an organization composed of utility companies providing transmission of electricity in the service area of WestConnect.

The members work collaboratively to assess stakeholder and market needs and to develop cost-effective enhancements or planning to the Western wholesale electricity market. WestConnect is broken up into multiple planning areas of which the Arizona utilities are located in the Southwest Area Transmission (SWAT) subregional planning group. SWAT is made up of transmission regulators and governmental entities, transmission users, transmission owners, transmission operators and environmental entities in southeastern California, southeastern Nevada, Arizona and New Mexico. SWAT's goal is to promote regional planning in the Desert Southwest.

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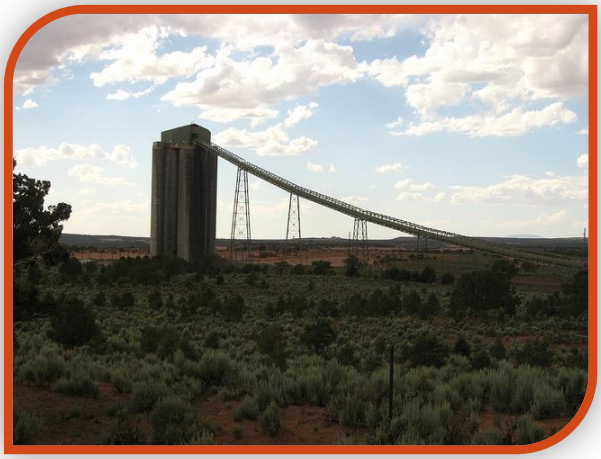
2. ARIZONA ENERGY RESOURCES

Arizona's major electrical generating sources are coal, natural gas, and nuclear. These sources serve the majority of the state's needs and will continue to play a primary role in Arizona's energy portfolio. Arizona generated over 110 million Megawatthours (MWh) in 2012, of which 92.2 percent was generated using these power generating sources.[5]

The state's renewable generating sources include hydroelectric, solar, wind, biomass, and geothermal. Some of these sources of power are growing but still remain small in comparison to the traditional power-generating sources. Of the more than 110 million MWh generated in Arizona during 2012, 7.5 percent was generated using these renewable generating sources with hydroelectric being the largest at 6 percent.

Arizona's growing population has led to growing demand for these energy resources. One way Arizona has led the charge to address this demand has been to use our current resources more efficiently rather than building more traditional supply-side resources. Not only does wisely managing Arizona's use of energy reduce the cost to citizens, it also reduces the impact to Arizona's waters and lands. These natural resources are inextricably linked to energy as it takes both land and water to make energy development and generation happen. Most electric generators use large amounts of water to reject heat, as much as a half-gallon per kilowatt-hour (KWh).



COAL

Current Status

Coal is one of the largest and oldest sources of energy generation in America and in Arizona it plays a major role in generating power for residents and businesses.[6] Coal is a fuel in which dead plant material is converted through biological and geological processes into a sedimentary deposit over a long period of time Coal produces over 36 percent of Arizona's net electrical generation and is the largest source of energy in the state. Although its overall share in the portfolio is declining, it still remains a crucial source of power.

There is only one commercial coal mining operation in Arizona, the Kayenta Mine. This mine has been operated for over 40 years by Peabody Energy through a business partnership with the Navajo Nation and Hopi Tribe.

All the production in the Kayenta mine goes to the Navajo Generating Station (NGS), which is operated by Salt River Project (SRP) and has a net summer capacity over 2,200 megawatts (MW). There are other large coal-powered generating stations in Arizona including the Springerville and Cholla Generating Stations, operated by Tucson Electric Power (TEP) and Arizona Public Service (APS) respectively, and each of these has a net summer capacity of over 1,000 MW.[7]

The Four Corners Generating Station in northwestern New Mexico also supplies a significant amount of power to Arizona and lists APS, SRP, and TEP among its owners. APS has recently pursued an agreement with Southern California Edison increasing APS' share of ownership to become the operator for the five units of the plant. If their agreement gains approval from state and federal regulators, APS has stated it will close the plant's three older, less efficient units and install additional emission controls on the remaining two units. Seventy-three percent of this plant's generation comes from the two newest units, and the closure of the less productive units will help in complying with EPA air emission regulations. APS estimates that this plan could save customers $500 million and may make it possible to avoid laying off workers.[8]

There are new technological developments for coal emissions currently being deployed in Arizona. Electrostatic precipitators, devices that collect particulate matter from moving air, are being used in coal-fired generating stations to capture fly ash. After the material has been collected, it can be recycled and used in cement, concrete, and other construction materials. Limestone is also being used as slurry to reduce sulfur dioxide emissions. When sulfur dioxide gas combines with crushed limestone, the chemical reaction between the sulfur dioxide, calcium and oxygen in the limestone creates a removable, recyclable solid waste instead of a greenhouse gas emission.

New technologies are not only being used in capturing emissions from coal-fired generators but also in engineering new methods of heating to reduce emissions. In Arizona, generating stations have started using new burners that control the size and branch of the flames used to burn coal. These new burners reduce nitrogen oxides.

Challenges

The challenges facing coal come from two primary sources:

- Compliance with and uncertainty regarding new EPA air rules and regulations.
- The challenges of a changing marketplace for all energy-generating fuels as new technologies in both fuel extraction and electrical generation emerge.

Currently Arizona utilities have no plans to build new coal facilities, in large part because of the regulatory environment and the associated compliance costs. For example, the EPA is considering regulating coal ash as either hazardous waste or as a non-hazardous solid waste. Other federal agencies are also considering new regulations for the coal industry.

In addition, since coal is predominantly composed of carbon, burning it releases carbon dioxide (CO_2), and federal agencies released rules restricting CO_2 emissions for existing power generation facilities on June 2, 2014.

The Clean Air Act (CAA) of 1970, updated in 1990, has been expanded in scope through Presidential Executive Order to regulate carbon dioxide emissions. New rules for future power plants were released in September 2013. Emerging technologies are being researched to address CO_2 emissions in coal plants such as coal gasification and carbon capture and sequestration (CCS). Though promising in the future, these are not currently commercially deployable and are unlikely to become economically viable anytime soon.

Exacerbating the complications from a new regulatory environment for coal are significant changes in the United States' energy market as a whole. Specifically, coal is being displaced by other resources, due partly to declining prices in other resources and partly to increased coal regulations. However, shifting too quickly away from coal could potentially:

- create significant economic issues in rural areas;
- aggravate price volatility;
- inflate costs that may be difficult for customers to absorb;
- complicate planning efforts;
- and increase water costs, thereby presenting new challenges to tribal entities and agricultural interests.

10-Year Outlook

Coal-fired generation in the U.S. faces significant challenges over the next 10 years. In Arizona, however, the adequate supply of coal for power generation means that coal will continue to be a significant part of the state's energy portfolio. On the other hand, most coal plants throughout Arizona are 30 to 50 years old, roughly the lifespan for which they were originally planned. The state's aging coal infrastructure will necessitate further life-cycle planning.

In addition to the Kayenta Mine producing coal supplies in Arizona, there was a significant development to solidify the importation of coal to rural Arizona. The Arizona Electric Power Cooperative (AEPCO) filed a complaint with the U.S. Surface Transportation Board (STB) challenging joint rates established by BNSF Railway and Union Pacific for transporting coal from the northern Powder River Basin and New Mexico to the Apache Generating Station near Cochise, Arizona. In 2013, the STB made a ruling in favor of AEPCO which provides an estimated $63 million in rate reductions and reparations after determining the freight railroad companies overcharged for coal shipments.[9]

However, new government regulations are creating uncertainty in the industry nationwide. The 2014 rules and regulations from the EPA have created uncertainty and may affect coal's future for energy generation. It is possible that these new rules will be the subject of legal action and, if they are litigated, coal's future could be even more unclear for an extended period of time.

The principal risk for coal could hinge on the outcome of the federal climate change debate, since coal produces more CO_2 than any other fossil fuel.

NGS serves as an example of how new rules and regulations are creating uncertainty. The EPA is regulating new emissions and has proposed mandating the installation of catalytic converters on the three 750 MW units at NGS. According to the operating entity, SRP, this would have cost $500 million. Instead SRP, and other stakeholders, developed an alternative proposal offering to close one of the units by 2020. This closure provides greater emissions reductions than the EPA's initial proposal, while also protecting the future operation of NGS and ensures reliable and affordable water and power.[10] The NGS directly employs over 500 people and the associated Kayenta Mine employs another 400 people; both facilities accounted for over $679 million in adjusted state tax revenues in 2011 dollars.[11] Preserving the continued operation of NGS is a paramount concern for Arizona, and the negotiation between SRP, the EPA, and other stakeholders is ongoing.

As new rules and regulations are released regarding carbon dioxide, the possibility for litigation exists, much like the EPA's rules and regulations regarding nitrogen oxides and sulfur oxides have led to litigation. For example, the Arizona Department of Environmental Quality (ADEQ) is in litigation with the EPA over regional haze regulations under the authority of CAA. Originally, Arizona's regional haze plan was submitted in 2003 and then updated in 2004; in January 2009, the EPA found that parts of the plan were incomplete and ADEQ has since amended it to address those concerns. The state has submitted its 2011 Regional Haze Implementation Plan to improve visibility in protected areas throughout Arizona.

ADEQ chose to litigate because the EPA did not take timely action on the state's implementation plan for regional haze and split the decision on Arizona's statewide plan into two parts.[12] On Dec. 5, 2012, the EPA took final action on a portion of Arizona's State Implementation Plan (SIP) regarding air pollution control at three coal-fired generating stations, disapproving the emissions limitation for sulfur dioxide at one generating station, and all three decisions regarding nitrogen oxides.

The EPA, on Dec. 21, 2012, partially approved and partially disapproved the balance of Arizona's Regional Haze plan, and ADEQ and EPA are continuing to work cooperatively to address this portion of the Regional Haze plan. However, on Jan. 31, 2013, the Arizona Attorney General's Office, in response to ADEQ's request, filed a petition for review with the Court of Appeals for the Ninth Circuit. On August 5, 2013, Arizona filed its opening merits brief with the Court and on August 19 was joined by the utilities. The EPA's consolidated response brief was submitted November 2013 and optional reply briefs will be due at the end of January 2014. Arizona argues within its brief that the EPA, in its proposed Federal Implementation Plan (FIP), ignores the CAA by disapproving Arizona's Best Available Retrofit Technology (BART) determinations for seven electric generating units at three coal-fired generating stations potentially costing the state's utilities and consumers hundreds of millions of dollars with no visually perceptible reduction in regional haze.

NATURAL GAS

Current Status

The United States has seen a fundamental shift in the natural gas marketplace. Natural gas consists of methane (CH_4) and is found beneath the surface The technological advances in extraction, primarily through hydraulic fracturing, have made the production of natural gas from shale and other unconventional resources readily accessible and, in recent years, have significantly increased domestic supplies. The abundance of domestic natural gas supplies has led to affordable energy prices across the nation and in Arizona over the last few years, and it appears this trend will continue for the foreseeable future.

Hydraulic fracturing is not a new technology, but recently it has become economically viable to extract natural gas from previously inaccessible sources. This increase in domestic supply has lead in part to a reduction in prices and displacement of other resources. Significant oil can also be extracted using fracturing, and some pundits predict the United States will be the leading oil and gas producer in five years.

All traditional generating resources use a large amount of water, but natural gas is a comparatively water-friendly generating resource. In addition to using less water to cool generating plants, burning natural gas produces nitrogen oxides and carbon dioxide in much lower quantities than other fossil fuel resources. Because natural gas uses less water and emits fewer regulated emissions, its overall environmental impact, in addition to low prices, is aiding a shift toward this resource.

Arizona produces very little natural gas, only 116 million cubic feet in 2012.[13] In comparison, states like Louisiana, New Mexico, and Texas produce millions of cubic feet of natural gas per day.[14]

Natural gas fuels 27.3 percent of Arizona's electrical energy generation. The state's use of natural gas peaked between 2007 and 2008, generating approximately 38.5 million MWh and has since tapered as low as 23.2 million MWh in 2011.

Natural gas is piped into Arizona from Texas and other Rocky Mountain states. Arizona is almost entirely dependent on natural gas imports and relies heavily on pipeline infrastructure to transport it where it is needed. There are approximately 5,000 miles of pipeline and two distribution terminals in Arizona.

Natural gas plants are quick to fire up during peak loads and start producing energy, making them the ideal resource to use in co-generation plants with renewable projects and balance overall load. Natural gas plants are also utilized.

Challenges

There are three primary challenges for natural gas in Arizona:

- The physical and cyber security of infrastructure.
- The volatility of commodity costs.
- The resiliency of natural gas delivery infrastructure.

Security requirements from the U.S. Department of Energy (DOE) are beginning to increase for all forms of energy and this could result in additional hurdles for natural gas pipelines and storage options. Arizona, to date, has experienced no security incidents in its natural gas infrastructure due to effective security systems in place. The utilities implement new technologies and methods as they become available to ensure security into the future; however, there can be compliance costs.

Seasonal storage in Arizona may be a way to mitigate price swings as well as create a more resilient and redundant delivery system.[15] Out-of-state storage is available but is also subject to the same transportation concerns. Developing in-state large-scale operational storage is not currently being pursued, due to economic issues, but has been considered previously in the form of developing underground salt caverns for storage. There are potential storage sites in existing salt deposits, including ones near Holbrook and Eloy.[16] In 2011, customers experienced an outage that utilities say was entirely preventable through storage.

Determining the future needs of natural gas pipeline capacity is challenging due to expanding use in the state and the increased demand in places like California and Mexico that also import natural gas, predominantly from Gulf States.

In October 2014, the fully subscribed Sierrita Pipeline began service from existing El Paso Natural Gas mainlines near Tucson, AZ to the US-Mexico border near Sasabe, AZ. This new system interconnects with a new international border crossing with a gas pipeline in Mexico and will help Mexico meet its environmental goal to convert its existing oil-fired electricity generation to future natural gas generation development.

Arizona, like much of the rest of the country, is on a trajectory to increase its reliance on natural gas-fueled power plants. This gradual shift towards more prominence for natural gas in our portfolio mix will require a forward-thinking plan for natural gas infrastructure and a strategy to reduce fuel-cost volatility. Cost volatility is of particular concern, because as stated, little to no production or storage capacity exists in Arizona today.

10-Year Outlook

According to a June 2013 Arizona Geological Survey (AGS) report, Arizona has an opportunity for natural gas extraction from the Mancos Shale formation, which is almost entirely restricted to Black Mesa Basin on the Navajo and Hopi Indian Reservations in the northeastern portion of the state.[17] The known productivity and total organic carbon content of dark Mancos Shale in New Mexico's nearby San Juan Basin suggests that hydrocarbon availability may be significant in the Black Mesa Basin using new drilling and production technology. However, this has not yet been tested and would require active participation by Native American tribes.

Recently, Arizona is deploying renewable technologies like Photovoltaic solar and wind; however, both are intermittent, meaning they are not generating power when the sun is not shining or the wind is not blowing. This creates a need for a dispatchable base-load resource, such as natural gas, to fill the gaps where these renewable resources are not creating energy.

Proper planning for Arizona's natural gas supply will reduce reliability concerns and could stabilize prices for Arizona power consumers. Arizona will need stakeholder, policymaker, and community support to facilitate pipeline and storage infrastructure development as demand increases and other states and international trade partners seek to take advantage of lower-cost natural gas supplies.

NUCLEAR

Current Status

The Palo Verde Nuclear Generating Station (PVNGS), operated by APS, is the largest nuclear plant in the United States and Arizona's sole nuclear generating station. The owners of the plant are APS; SRP; El Paso Electric Co.; Southern California Edison; Public Service Co. of New Mexico; Southern California Public Power Authority; and Los Angeles Dept. of Water & Power. Nuclear generation produces the second most power in Arizona's net electrical energy generation portfolio and produced 31.9 million MWh in 2012.[18] The PVNGS has installed capacity of 3,900 MW, produced by three units and the current license lasts through 2047.[19]

This source of power is commonly generated through nuclear fission, or splitting atoms. The most common of these is an isotope of uranium, U235.

Arizona has significant uranium resources and has mined it in the past. However, due to a moratorium from the federal government Arizona is prohibited from mining in an area of one-million acres on the Colorado Plateau in northern Arizona. While there are development opportunities for using fuels other than uranium for developing nuclear generation, uranium remains the fuel of choice due to existing mining and enrichment infrastructure and the relative abundance of uranium around the world.

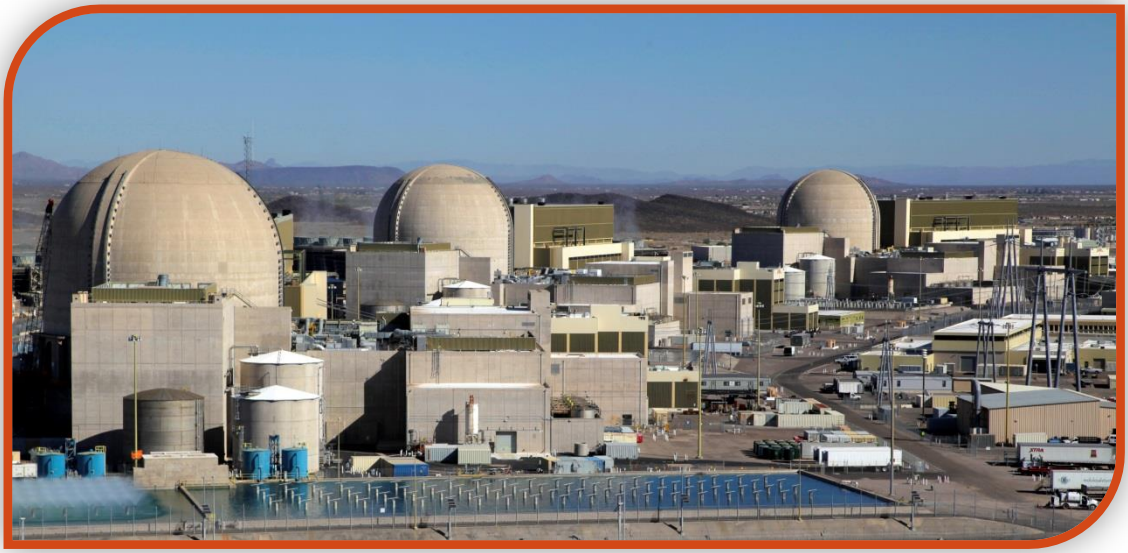


Photo Courtesy of Arizona Public Service

Palo Verde Nuclear Generation Station produces zero carbon emissions. According to APS, its operation has offset close to 484 million tons of CO_2 since the plant opened in 1988. This is equal to taking up to 84 million cars off the road.[20]

Nuclear generation features a low price per KWh for base-load power in Arizona and will remain a very cost-effective source. PVNGS is a base-load resource with zero atmosphere emissions and has a significant economic impact on Arizona in terms of taxes, jobs, and revenue generation. Specifically, the plant's owners pay an estimated $55 million in property taxes on the PVNGS which directly employs 2,300 people and 1,400 contractors. PVNGS created an annual economic impact of $1.8 billion on the Arizona economy in 2009.[21]

Challenges

Nuclear Generation has four primary challenges:

- The biggest challenge for new nuclear generation is the significant cost of developing nuclear projects. They require large capital investments and pose significant risk of no return on investment.
- According to the Arizona Geological Survey (AGS), any potential global uranium shortage could impact Arizona and subject nuclear generation to political developments.
- Long regulatory time lag coupled with regulatory uncertainty can increase upfront costs.
- The amount of natural resources needed to operate a plant is high. However, PVNGS is the only nuclear-generating station in the world that is not located near a large body of water; it is cooled entirely by reclaimed water, and this system has functioned flawlessly during its operation.

Although, nuclear generating stations are strategically important, some have inherent homeland security concerns. The Nuclear Regulatory Commission (NRC), along with the Federal Emergency Management Administration (FEMA), regulates these concerns. Compliance with

federal regulations can often be expensive and prohibitive for new power-generation opportunities.

Another key nuclear issue is the development of spent fuel storage facilities, and there are significant political and environmental issues with their development. Currently, almost all nuclear waste is stored on site at nuclear plants across the U.S. In fact, PVNGS has the second largest spent fuel inventory in the U.S.[22] Expert panels that have looked at the issue of permanent disposal have come to the conclusion that deep geologic disposal is the preferred approach.

To explore this issue, the Blue Ribbon Commission on America's Nuclear Future was established as directed by the President's Memorandum to the Secretary of Energy in 2010. The first recommendation in the final report of the Disposal Subcommittee of the Commission was: "The United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste." The subcommittee explained its reasoning, saying "[t]he Subcommittee further concludes that geologic disposal in a mined repository is the most promising and technically accepted option available for safely isolating high-level nuclear wastes for very long periods of time."[23] However, establishing a permanent disposal site has been an ongoing national issue for decades and developing a site is going to remain difficult as it is a "not-in-my-back-yard" issue.

10-Year Outlook

Nuclear power plant construction stopped for several years throughout the country, but there are now plans to build four to eight new nuclear plants in the U.S. by 2020, according to the Nuclear Energy Institute (NEI).[24] Currently, construction has begun for five nuclear reactors in the U.S.[24] Within the foreseeable future, Arizona is unlikely to see large-scale nuclear generation development.

Alternative smaller-scale nuclear technologies could emerge over the next 10 years. NuScale, a company majority-owned by Fluor, has made publicly available its design and plans to develop a Small Modular Reactor (SMR) that offers the benefits of nuclear power while eliminating some of the issues presented by constructing a large power plant. This power module has potential to produce more than 45 MW with its own designated turbine-generator set. The power plant is scalable and additional modules can be added as demand for electricity increases. A single plant can include as many as 12 power modules to produce at least 540 MW.

Companies like Westinghouse are also considering this new nuclear option, while others are exploring alternative nuclear fuels like thorium instead of uranium[25] and creating molten salt reactors.[26] Finally, research continues on harnessing controlled fusion technology using hydrogen isotopes to generate heat to produce electricity. Fusion has been demonstrated on a small scale; however, practical fusion-generation remains experimental.

HYDROELECTRIC

Photo Courtesy of Salt River Project

Mid-progress photo of the Theodore Roosevelt Dam, which turned 100 years old in 2011. This was the first major structure the Bureau of Reclamation constructed on the Salt River Project completed in 1911 and located 76 miles northeast of Phoenix.

Current Status

Hydroelectric generation is the oldest and largest source of renewable energy in Arizona. From 1905-1911, the U.S. Bureau of Reclamation constructed its first hydroelectric power project, the Theodore Roosevelt Dam on the Salt River in Arizona. In 2012, hydroelectric produced almost 6.7 million MWh, roughly 6 percent of the electric power generation for that year. However, hydroelectric generation is variable over time and subject to precipitation patterns. From 2001 to 2012, the average annual hydroelectric generation was 7.2 million MWh. The lowest was 6.4 million MWh in 2005 and the highest was almost 9.2 million MWh in 2012.

While hydroelectric power represents a small portion of Arizona's total energy generation portfolio, it provides significant benefits to energy and water users, including facilitating the integration of other renewable resources and providing ancillary services like irrigating farmland. Hydroelectric dams provide consistent water to farmers, boosting the agricultural industry and population growth in the arid climate zones.

Smaller-scale hydroelectric generation is beginning to gain support. As an example, Natel Energy Inc. completed the installation of its first commercial small hydro project last year in Buckeye, in partnership with the Buckeye Water Conservation and Drainage District. In addition, both Central Irrigation and Drainage District and Maricopa-Stanfield Irrigation &

Drainage District in Pinal County have potential to generate electricity through small scale hydroelectric generation; however, regulations governing these systems make development cost-prohibitive.[27] Also, subsidies for small-scale hydroelectric generation are less significant than those for other renewable resources. With these minor exceptions, hydroelectric generation capacity in Arizona is essentially at full potential.

Challenges

Environmental issues, such as decreased precipitation and water management in environmentally sensitive areas, are key challenges for hydroelectric generation.[28] It is important for Arizona's economy to preserve the state's Colorado River allotment and to ensure that water resources are allocated fairly. The Arizona Department of Water Resources promotes, protects and manages Arizona's entitlement of 2.8 million acre-feet annually of Colorado River water. The Arizona Power Authority is the steward of Arizona's major hydro allocation from the Hoover Dam.

10-Year Outlook

The future development of new hydroelectric generation in Arizona is likely to be smaller, more localized projects. These small-scale projects may positively impact local areas but will not greatly impact the state's overall energy portfolio.

Arizona has largely maximized its use of hydroelectric power with our existing dams and pumped storage and there are no known plans for further development.

Photo Courtesy of American Solar Electric

SOLAR

Current Status

Since before statehood, Arizona has provided leadership in solar energy research, development, and deployment. In the 1800s, Arizona used solar for heating and pumping water; more recently, the state has enacted numerous solar tax incentive programs for businesses and citizens.

Solar generation is rapidly growing in Arizona. In 2012, Arizona came close to generating 955,443 MWh, a substantial increase over the 83,350 MWh of solar energy generated in 2011 and 15,754 MWh in 2010. In 2012, the state installed more

utility scale solar than any other state[29] which in 2013 resulted in enough solar energy to power 145,500 homes.

As a result of this rapid development, Arizona has more than 275 companies and 9,800 employees in the solar supply chain. In response to this growing energy sector and to aid in facilitating its growth, Governor Brewer formed the Solar Energy Advisory Task Force. This task force identified ways to streamline permitting, make installations easier and more affordable, and suggest potential policy reforms and initiatives.

The state is also a leader in the deployment of solar for heating and pumping water. Solar water heaters are reliable, time-tested technologies that can significantly decrease a residence's electricity use. Water heating in the home uses 80.6% of a household's entire use of electricity.[30] The average household uses about 10,000 gallons of water per month, which equals 300kWh of embedded electricity.

Arizona encourages the installation of solar water heaters in homes and businesses through many of its renewable energy incentives and tax credits:

- Arizona's Solar and Wind Equipment Sales Tax Exemption, Non-residential solar & wind tax credit (Corporate & Personal);
- Renewable Energy Business Tax Incentives;
- Residential Solar and Wind Energy Systems Tax Credit;
- Energy Equipment Property Tax Exemption
- Solar and Wind Equipment Sales Tax Exemption, all can be applied to solar water heaters.

Solar generation has become an important piece in Arizona's portfolio. Photovoltaic (PV) solar panels on private residences and businesses were rare until recently, but significant changes in the industry and policy are making them more common. PV panels have been reduced in cost; between 1998 and 2011, installation prices declined 5 to 7 percent per year and from 2010 to 2011 those prices fell between 10 and 14 percent.[31] Experts predict more decreases in long-term prices, and the DOE is committed to seeing those prices fall.

With the goal of reducing the cost of solar, DOE began its SunShot Initiative in 2011 in order to make solar generation cost-competitive with other forms of electricity by the end of the decade. In December 2011, the Arizona Governor's Office of Energy Policy (GOEP) was awarded almost $709,000 for Arizona's Rooftop Solar Challenge (ARC), a program which identified best permitting practices statewide. Additionally, less-expensive long-term solar prices, in combination with an infusion of research and development capital, have given the solar industry a strong foothold towards growth.

Distributed generation from residences and businesses has seen a significant increase recently. In addition to the lower costs and government subsidies driving more solar installations, some private companies use leasing to make solar available for home and business owners. Residential utility customers who want PV panels on their homes but lack the funds needed to

finance the upfront costs have another option through a regular payment to a solar leasing company that will install the panels, as well as finance most of the installation. Arizona homes that use higher amounts of electricity could potentially see a net decrease in their monthly bills as the leased PV panels offset their utility bills. In 2014, both Tucson Electric Power and Arizona Public Service put forward plans to the Arizona Corporation Commission (ACC) to develop residential solar programs within their service territories.

In 2013, the ACC established a new policy regarding net metering which will affect the utility bills of some Arizona customers with solar systems. This new policy addresses bridging the value gap which occurs between solar and non-solar customers and sets in place an approximate $5 monthly charge for the average residential PV system, and approximately $7 for larger systems that produce 16 KW or more. This was established to help the utilities maintain and repair electrical infrastructure which all customers use. The new policy also created a quarterly review process to measure market demand and a new docket to discuss other technology issues. In 2014, Salt River Project put forward a similar proposal to address the value gap in their service territory. In their proposal they include an incentive to orient solar project towards the west as opposed to the south to better meet peak-use demand on the grid.

Photo courtesy of National Renewable Energy Laboratory

Light is reflected in a 25 ft. wide, 500 ft. long and 10 ft. high parabolic trough collector at Abengoa's Solana Plant. Solana is a 280 megawatt utility-scale solar power plant (CSP) located in Gila Bend Arizona.

PV panels and Concentrated Solar Power (CSP) both generate energy at utility scale. The difference being that PV panels convert electricity through a photoelectric reaction while CSP heats water, which then drives a turbine much like the process used in traditional generating stations. Arizona has pioneered new solar generation using both methods. The state is home to the world's largest operational PV solar generating facility in Yuma, the Agua Caliente Solar Plant, which uses PV panels manufactured by Arizona's largest PV panel manufacturer, First Solar. It currently produces approximately 250 MW under perfect conditions.[32] The Solana Generating Station, near Gila Bend, is a CSP plant utilizing solar thermal energy storage. At maximum output it produces 280 MW.[33] Two other large PV-generating plants are the Mesquite Solar Plant and Arlington Valley Solar Energy II that produce 150 MW and 125 MW respectively.[34] One of the benefits to

utility-scale PV generation is that its water use is significantly less than CSP, essentially zero for PV.

The rapid development of both distributed and utility generation has affected Arizona's economy and job outlook. Each utility scale solar project employs hundreds of construction and technical workers. Distributed generation, either through direct purchasing or leasing, creates jobs for people specializing in their installation. For example, Solana created over 2,000 construction jobs and 85 permanent jobs. These numbers do not take into effect the number of indirect jobs created as a result of the injection of capital into the community and state.

This increase in economic activity and job creation is due in large part to a hospitable regulatory environment and some government subsidies. As an example, the state's Renewable Energy Tax Incentives Program (RETIP) which offers two benefits:

- Up to a 10 percent refundable income tax credit.
- Up to a 75 percent reduction on real and personal property taxes.

Another program is the Renewable Energy Production Tax Credit that is intended to promote investment in renewable energy production projects over 5 MW with low, or zero, emissions.[35] In addition, the Commercial/Industrial Solar Energy Tax Credit Program is designed to stimulate the production and use of solar energy in commercial and industrial applications by subsidizing the initial costs. The program achieves its goal through an income tax credit for the installation of solar energy devices in businesses.[36]

Challenges

Solar energy generation is expanding and will continue to develop in Arizona in the coming years. The rate at which the solar industry expands will depend in part on the appropriate regulatory bodies' decisions on issues such as net metering, cost of distribution, transmission and decoupling. Insuring solar generation in the future will rely heavily on developing technology that addresses intermittency and cost-competitiveness issues.

Arizona faces three primary challenges in the solar industry:

- Decreasing demand
- Financing
- Restricted export of generation

Decreasing demand has recently become an issue. Arizona's regulated utilities are reportedly ahead of their Renewable Energy Standard and Tariff (REST) goals. The REST goals, put in place by the ACC in 2006, state that by 2025 regulated utilities in Arizona must get 15 percent of their generation from renewable sources.

Financing the construction and installation of solar projects will remain an issue. Despite declining prices, these technologies are not yet at cost parity with traditional fuel sources. Competition with cheaper and near-clean sources will be a challenge for solar generation until the price point is more competitive with other generation resources.

The fact that Arizona exports a large amount of energy to neighboring states and potentially to Mexico, presents a challenge as our transmission infrastructure nears capacity. As our neighbors pursue their own versions of REST goals, the demand for renewable energy could increase.

Because of its climate, Arizona is in a good position to take advantage of this potential demand. However, if this potential is to be realized, Arizona must meet the challenge of new siting and construction of energy transmission.

10-Year Outlook

Solar is not expected to displace large amounts of base-load power in the next 10 years, given issues with intermittency and efficiency, as well as some regulatory uncertainty related to the industry's development.

Arizona will need between 7.9 million MWh and 8.5 million MWh of renewable energy in 2025 to meet the REST target of 15 percent. Arizona is projected to have enough high-quality solar energy to meet the forecasted requirement.[37] Current or developing renewable electricity projects as of 2012 can supply 3.2 Terawatthours (TWh) annually.

Most of the years between 2013 and 2023 will have likely little solar demand coming from the state's utilities, assuming federal and state laws remain the same. Also, demand from California and Mexico may start to drive export projects, which could present an opportunity for the Arizona State Land Department to explore development opportunities. However, an extended period without meaningful utility-scale solar demand or viable distributed generation programs could have a significant effect on the industry.

However, Arizona does have cause for optimism for solar over the next 10 years. The solar-leasing model is growing because it mitigates some financing concerns for customers. The declining cost of materials, the increasing efficiency of the technology, and a more efficient permitting process for deployment in the solar industry are also positive signs for developers. During the next 10 years, the solar industry is targeting 9 cents per kWh, and this price point would make solar generation competitive with traditional generating resources.

WIND

Photo courtesy of National Renewable Energy Laboratory

Current Status

Wind energy was the fastest-growing electrical energy source in the U.S., providing 42 percent of the new generating capacity in 2012.[38]

In many areas, wind energy is cost-competitive with natural gas. Some utilities are reportedly purchasing wind energy due to its low cost, hedge value against fossil fuel price increases, and long-term price stability. In Arizona, commercial wind projects produce energy about 30 percent of the time.

Wind turbines turn the wind's kinetic power into mechanical energy to produce electricity. Small increases in wind speed dramatically increase power output, making siting selection and the placement of wind turbines extremely important.

Wind turbines come in many sizes, from small, distributed machines of under 100 kilowatts that can power a home or ranch to utility-scale machines of 1.5-3.0 MW that can power thousands of homes. The largest wind machines, used off-shore, are 7.5 MW. Utility-scale wind turbines have three blades and stand on single pole structures that are often higher than a football field.

The National Renewable Energy Laboratory (NREL) estimates that Arizona's wind-energy generation potential is over 10,000 MW. The state currently has five installed wind projects with a combined capacity of 238 MW, representing enough energy to power 55,000 homes:

- Dry Lake Wind Farm, located in Navajo County, between Holbrook and Heber, is a 126 MW project made up of sixty 2.1 MW turbines. The project was built on a combination of private, U.S. Bureau of Land Management and State Trust Lands. Salt River Project purchases all the electricity from the project.
- Perrin Ranch Wind Energy Center in Coconino County is a 99.2 MW project that provides electricity to Arizona Public Service Company. Sixty-two 1.6 MW turbines provide enough electricity for 29,000 homes.
- Unisource Electric will purchase energy from a unique 10.5 MW combined wind and solar photovoltaic system near Kingman that will power more than 2,200 homes.
- In 2014, Tucson Electric Power will begin receiving 51 MW of wind power from the Red Horse Wind Facility near Willcox.

Other projects are under development, including a 400 MW wind project that BP is exploring near Kingman. All of Arizona's major utilities have wind power in their portfolios and Northern Arizona University is a national leader in wind-energy research.

Challenges

Wind energy is a site-specific resource, often located far from people and existing transmission lines. New or upgraded transmission lines may be needed to accommodate significant new projects. To manage wind's natural variability, utilities must use modern system planning and integration tools. Finally, federal tax support (called the Production Tax Credit) has been unstable, causing a boom-and-bust cycle for the wind industry in project development and manufacturing.

Wind also presents a challenge to wildlife preservation. A recent study by the U.S. Fish and Wildlife Service says that wind turbines killed 85 golden and bald eagles between 1997 and 2012 and speculated that the number could even be higher.[39] As a result of lawsuits in California, wind turbines have been forced to shut down during migration season in order to protect wildlife, specifically golden eagles and red tail hawks. In anticipation of expanding wind turbine development in Arizona, the Arizona Game and Fish Department released guidelines for their development in 2009 to mitigate the impact of wind turbines to the state's bird and bat populations.[40]

10-Year Outlook

Most existing wind projects in Arizona have been built without significant new transmission investments, but the development of additional projects may be increasingly constrained by transmission limitations.

Wind energy has desirable characteristics that make it an attractive choice for utilities. Wind turbines have extremely high reliability, and increasingly sophisticated meteorological forecasting software is making wind project output more predictable.

New lower-speed wind turbines are allowing projects to be developed in what were once considered marginal wind resource areas, opening up significantly more potential development in Arizona.

Wind energy development is compatible with existing land uses of ranching and farming and can provide significant revenues to rural counties. For example, Navajo County receives approximately $800,000 in tax revenues from its 126 MW wind project.

Wind energy enjoys popular support because of its long-term price stability, environmental benefits, and the fact that wind generators consume no water. These characteristics make it an attractive renewable power source for Arizona's growing electrical needs.

BIOMASS

Current Status

Biomass is organic material, such as forest waste, feedstock and algae, which can be combusted to generate heat, which in turn can be used to produce useful forms of energy for industrial and other processes. Additionally, biomass materials can be modified to produce liquid or gaseous fuels for use in internal combustion engines that power vehicles. Many of the nation's biomass startup operations aim to capture the energy contained in various forms of organic material and put it to use as a fuel or heat source.

Another type of biomass generation is through the use of waste gas. Arizona has three operational Landfill Methane Projects generating renewable energy. They are located in Tucson (Tucson Electric Power - 2.4 MW), Scottsdale (Salt River Project - 4 MW) and Glendale (Arizona Public Service - 2.8 MW). These capture landfill gas or methane to produce energy.

Challenges

Arizona faces two major challenges in using forest waste to produce energy:

- The crisis state of fire-prone large conifer forests located on federal, state and private lands.
- The operations entailed in energy generation from biomass.

Our forests are vulnerable because neglect and inconsistent forest management practices have created ideal conditions for fires. Officials at various levels of government are now acting to create a safer forest environment, primarily through thinning. Although environmental groups have long opposed thinning which has delayed progress in creating safer forest environments, there is now general agreement that something must be done.

Arizona, in collaboration with the federal government, is developing a program to begin a massive thinning effort. At first glance, this program appears to present a golden opportunity to utilize the resultant biomass to produce a new energy source. However, it is estimated that this program will take many decades to complete and ensure certainty of supply. Nevertheless, many entities are eyeing this potential, and in fact, some pilot activity has already taken place. Good Earth Power AZ LLC was approved to thin 300,000 acres of land in four of Arizona's forests over the next ten years.

Generating energy from biomass presents another challenge as well. In 2008, a power plant was constructed in northeastern Arizona. The plant uses wood from the forest thinning and other resources to fuel its operations and generates 24 MW of electricity. Because of the scarcity of fuel the plant initially ran into problems. And although the original owners were not successful, the plant was acquired in 2013 by Novo Power, LLC, and is once again in full operation.[41]

This example illustrates the most daunting challenge facing an operation – using materials gathered from far and wide. One solution lies in creating a central location for biomass. For example, a central location for feedstock would eliminate some of the costs that originally plagued the northeastern Arizona plant. A further advantage to this approach is that proper crop choice can result in desirable fuels, such as combustible liquids. Today's robust ethanol market, using corn and corn waste to produce a liquid fuel possessing many of the characteristics of gasoline, has found considerable acceptance around the country. The limited water supplies found in much of the western U.S. preclude large-scale farming operations for liquid-fuels generation. Most of the feedstock for ethanol in commercial use is grown in the Midwest, where water is much more plentiful that it is in Arizona. One of the unintended consequences of this effort has been perturbations to the food industry, in the case of corn.

10-Year Outlook

A sizable ongoing market exists for ethanol as an automotive fuel, or as an oxygenate additive to gasoline to meet environmental emission standards. Earlier oxygenates such as MTBE have been determined to possess dangerous health hazards and are no longer in use. Another possibility is a pure energy play by growing a species with no other commercial use. Such a species is genetically modified algae. Because less water is needed to grow the "crop," and the growth cycle is extremely short (days or weeks instead of a year), it can be grown in states like Arizona which have limited water supplies. Again, the details: everyday algae, the green material on small stagnant bodies of water does not produce high yields of liquid fuels such as ethanol and butanol, so companies have genetically modified algae to greatly increase the yield.

When these algae are grown in open systems, such as ponds or ditches, the native, low-yield species present in the air invade the facility and soon overwhelm the modified form. The result is lower yields. To overcome this, producers must use a closed system, whose capital cost is currently so high that the facility can lose its economic viability. Nonetheless, work continues to develop strains resistant to this problem. If successful, people may someday enjoy a supply of liquid engine fuel that is "home-grown." Finally, there are a myriad of small efforts around the country which strive to utilize locally available materials to convert into energy stocks. These are essentially boutique applications, which make sense in a local area, but do not promise to materially increase global fuel supplies.

GEOTHERMAL

Current Status

Large geothermal electrical power plants have not been developed in Arizona, but several power plants are currently in operation just west of Yuma in the southeastern California's Imperial Valley.

Photo courtesy of National Renewable Energy Laboratory

Arizona Public Service geothermal test drilling project near Clifton, Arizona.

SRP has signed a 30-year agreement to purchase the entire output of the Hudson Ranch 1 project[42], a 50-megawatt (MW) geothermal power generation project to serve Arizona customers in its service territory. Although some high temperature geothermal resources exist southeast of Phoenix near the now-retired Williams Air Force Base, they have never been considered economically viable to develop.[43]

Enhanced Geothermal Systems (EGS) is the newest method for large-scale geothermal being deployed in the world today. An EGS generates geothermal electricity without the need for natural convective hydrothermal resources like those utilizing naturally occurring heat, water, and rock. However, by far the most geothermal energy within reach of conventional techniques is in dry and impermeable rock, like that found in Arizona. EGS technologies enhance and/or create geothermal resources in this hot dry rock through hydraulic stimulation.

Arizona has significant geothermal potential in direct-use application, with over 1,250 separate thermal wells and springs. The two highest-temperature springs in the state are Clifton and Gillard, both in the Clifton-Morenci area of eastern Arizona. The water temperature at these springs ranges from 158 to 180° F.

Arizona mainly focuses on these direct-use applications: heating buildings, growing plants in greenhouses and heating water at fish farms. The state is a national leader in the aquacultural use of geothermal fluids to extend the growing season of agricultural crops. At least one algae biofuel operation and six fish hatcheries in Arizona use geothermal waters to keep an ideal temperature for year-round growth. In addition, DOE funding enabled a company to install geothermal heating to a 7.5-acre tomato greenhouse complex near Willcox in southeast Arizona.

A system of thermal energy known as a Geothermal Heat Pump System does not rely on thermal springs, but on shallow low-temperature systems in ordinary rock and soil. The temperature underneath the ground remains approximately 50° F at all times, morning and night during all seasons of the year. The system uses this constant underground temperature to regulate air temperature inside a building, acting as a heat source in the winter and a heat sink in the summer.

As an example, Lookout Mountain Elementary School in the Washington School District uses a closed-loop, ground-source system with simple tap water as the circulating fluid to heat and cool a 50,000-square-foot wing of the school. This is part of the district's program to operate sustainable and environmentally efficient schools. The ground-source geothermal heating and cooling system conditions about 50 percent of the school complex, including classrooms, the cafeteria and gym.

These systems use pumps to circulate a working fluid, usually water or antifreeze, through buried pipes. While circulating underground, the temperature of the working fluid approaches that of the surrounding earth. The working fluid is then pumped back to the surface, where it is used to absorb or release heat through a heat exchange system.

Challenges

Large-scale geothermal resource extraction process may not be feasible given Arizona's geologic composition and because there are minimal financial incentives for geothermal power plant companies to develop. In addition, potential EGS systems are being scrutinized both for concerns over possible induced seismicity and because of the large amount of water that is necessary for the process.

It is possible to use thermal energy extracted from the ground to directly heat building spaces, few sites exist that make this a major application in Arizona. However, lower-quality ground thermal resources can be amplified by mechanical equipment to provide heating and cooling at higher efficiency and lower operating cost. Several tradeoffs have impeded this becoming a mainstream application. First, the initial capital outlay can be prohibitive. Even if the long-term payback is acceptable, financing is a problem, because lenders are reluctant to accept the payback analysis. Second, many such systems have a large footprint, which is often untenable. Finally, there is no established, robust industry for this application, which can deter potential development.

Despite these obstacles, there are advantages in EGS systems. Since there is no heat-exchange with ambient air in the condensing portion of a geothermal vapor-compression system, all the components can be securely located inside a building, away from people intent on theft of components such as copper tubing. Another advantage of an indoor system over one that encounters the elements is its efficiency.

The cost of Geothermal Heat Pump System installation is still relatively high. This stems in large part from the installation cost. Although there are some state and federal incentives available, some entities opt for less-expensive alternatives because of these up-front costs. A possible approach to increasing utilization of these systems would be to develop community geothermal systems, wherein a complete subdivision of homes or small businesses could couple into the main system, with individual sub-metering of each user's draw.

10-Year Outlook

The AGS first explored Arizona's geothermal possibilities in the late 1970s. Although geothermal potential was considered high, by the mid-1980s lack of funding mechanisms squelched further exploration. AGS is now encouraging industry to renew exploratory efforts by making geothermal resource data available online, including well and temperature data from more than 2,400 oil and gas geophysical logs. According to AGS there may be future potential for EGS in Arizona and there are some parties with proposals out to test the theory. Start-up costs can be higher for geothermal power generation than for similar solar or wind systems, so national investment would be needed to promote large scale operations.

The Governor's Office of Energy Policy (GOEP) has taken an active role over the past few years to increase industry and public awareness of geothermal technologies and applications:

- Three geothermal workshops have led to increased knowledge among developers and installers about approaches to drive down costs of systems, and strategies to promote the benefits of Geothermal Heat Pumps to consumers.
- The GOEP has also participated in the facilitation of some systems being installed at local schools.
- Moving forward, the GOEP will continue to provide a forum for the industry to help expedite more wide-spread adoption – from financing alternatives to installations – of geothermal usage throughout the state.

There is large potential to expand the use of Geothermal Heat Pump Systems to increase efficiency for heating and cooling. Continued work to address efficiencies in permitting and installations should help mitigate the costs and grow the geothermal market in Arizona.

ENERGY EFFICIENCY

Current Status

Energy efficiency offers promising opportunities for Arizona to cost effectively meet its future energy needs. Whether it is sealing leaky air conditioning systems, upgrading equipment and lighting in small businesses, or implementing processing improvements at manufacturing facilities, all Arizonans stand to benefit from steps taken toward a more energy-efficient economy.

Not only is energy efficiency less costly than traditional supply-side resources, it also provides benefits to the local economy by supporting local contractors and producing bill savings for customers who take advantage of efficiency measures.

Arizona businesses, homeowners, and utility companies have increasingly invested in energy efficiency to meet energy needs. According to the American Council for an Energy-Efficient Economy, Arizona's rank among U.S. states for energy efficiency improved from 29th in 2009 to 12th in 2013.[44] This success, as seen in Figure 16 below, can be largely attributed to policies and efforts undertaken by Arizona's utilities, their regulators, and local and state governments that see the long-term benefits of investing in energy efficiency.

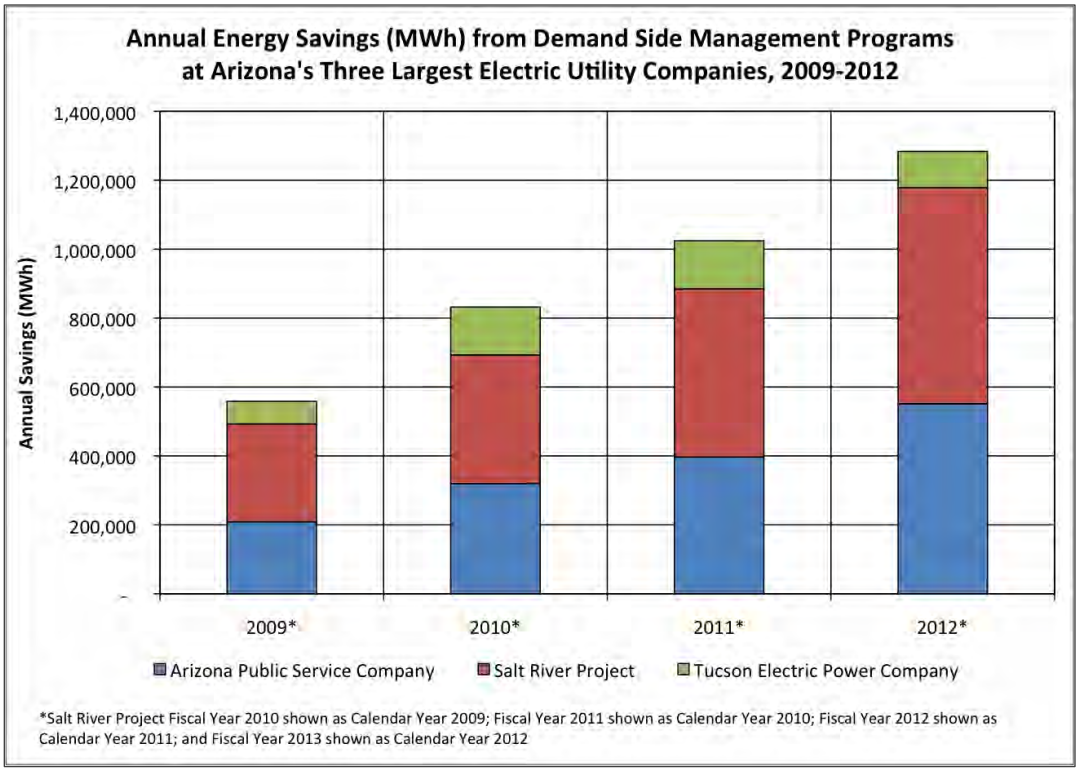


Figure 16

For example, in 2006 the state established a property tax exemption for energy-efficient building components and in 2008 adopted efficiency standards for certain appliances.
A study by the National Academy of Sciences found that by 2030 more energy-efficiency technologies would be used if barriers to adopting them were reduced, resulting in a 20 to 30 percent reduction in efficiency costs. In addition, in 2010, the ACC approved Energy Efficiency Rules requiring electrical utilities to achieve energy savings of 22 percent of their previous year's retail electric sales by 2020. [45] However, in 2014 the ACC opened a docket and staff submitted rules to amend the original standards to instead be goals. As outlined in the Executive Summary, Arizona is in the process of initiating several efforts to "lead by example" by reducing barriers.

Among those efforts are addressing energy use in government facilities, establishing partnerships between Arizona Department of Administration (ADOA) and the State Procurement Office (SPO) to develop a state energy-savings and performance-financing contracts, and creating a new pre-qualified list of Energy Performance Contractors (EPCs) through the SPO State Cooperative Contract. All these efforts simplify potential consumers' ability to use energy efficiency.

EPCs have been used by public and private customers for over 20 years and have been proven to be an effective method for upgrading existing facilities, although some state agencies have been unable to engage in such contracts due in part to the economic downturn. The EPC form of modified project delivery system has been extensively used by school districts and the universities.

Photo Courtesy Pinal County

There is traditionally an assumption that manufacturing facilities will consume significant resources, especially energy. Large manufacturing plants employ a large amount of people to do a large amount of work and often that work takes significant energy and water.

Frito-Lay celebrates its 30th anniversary in 2014 manufacturing at the Casa Grande facility, and they have made a near net zero commitment to changing the energy intensive assumptions of manufacturing. They have committed to reducing water reduction by installing new technologies that recycle 50 to 75% of water. In 2009 the Casa Grande Frito Lay facility became the first existing food manufacturing site to earn LEED Existing Building Gold Certification from the U.S. Green Building Council.

This Casa Grande facility has changed the assumptions of energy in manufacturing and shows no sign of slowing down their commitment.

Challenges

Energy efficiency, despite its obvious benefits, faces challenges that reduce its use, such as:

- A lack of access to capital.
- Appropriate training for appraisers.
- A public unaware of its inherent value and economic viability.
- Inadequate tools for financiers to evaluate the benefits.

To increase access to capital for energy efficiency, appraisers need the tools to evaluate and comprehensively appraise buildings to include energy consumption. Providing training in energy indexes to educate appraisers would enable them to more accurately assess the building's worth and operating costs; additionally, energy indexes could help appraisers determine building costs lowered by energy-efficient technologies. As a result, more accurate estimates could transfer to the financial markets proving to financiers that energy efficiency is a viable investment.

This fundamental lack of public knowledge of energy efficiency's value is arguably the most significant challenge to increasing the energy-efficiency market. Education of the general public, the real-estate industry, contractors and financiers must include:

- Helping consumers understand the benefits related to decreased energy bills and the true cost of home ownership.
- Educating realtors on the added value of energy efficiency in homes and buildings.
- Offering classes on energy indexes.
- Training contractors on rating systems and efficiency codes such as the Home Energy Rating System (HERS), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard and the International Energy Efficiency Code (IECC).
- Making financiers aware of energy-efficiency loan programs.

A home with certified energy-efficiency construction, such as storm windows, high-efficiency heating and cooling equipment and better insulation, will cost less to live in than one without these features. Buyers who were approved for a loan of a certain amount can borrow additional funds to either cover built-in efficiency measures or to install them. Lending institutions that provide mortgages for homebuyers are typically concerned with two things: the amount of the proposed loan and the ability of the buyer to service the loan. They consider, among other things, the borrower's income and present debt load. If the lending community is aware of energy-efficiency loan programs, they may be more willing to provide access to capital taking into account the utility savings and how that affects the overall mortgage.

10-Year Outlook

Each of Arizona's major electric utilities has set goals for the next decade that rely heavily on energy efficiency to meet their customers' energy needs.

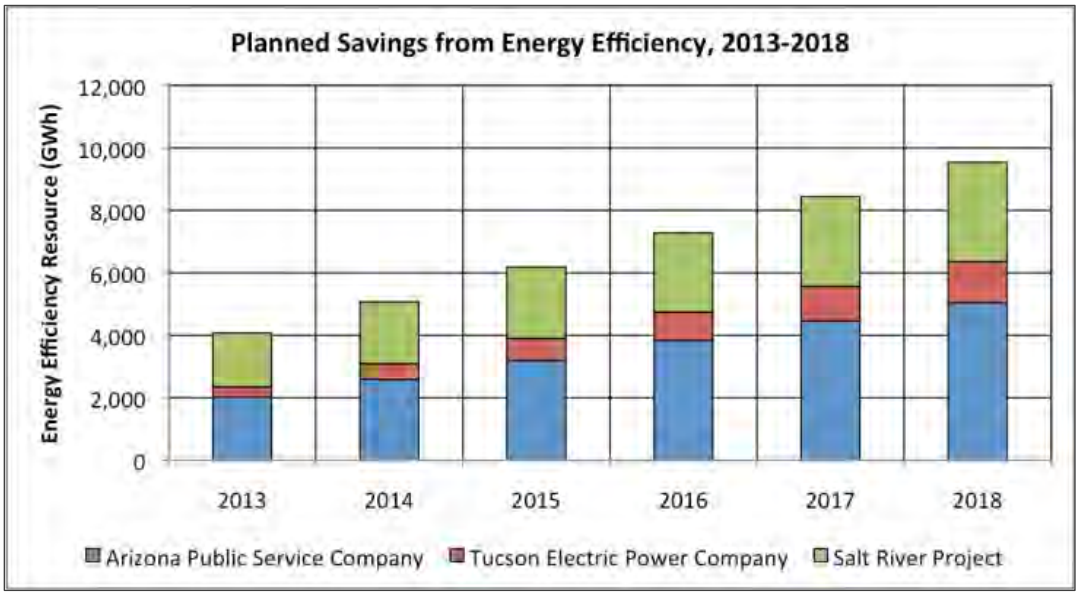


Figure 17
Sources: APS 2012 IRP, Base Case Scenario, Attachment F.1(a); TEP 2012 IRP, Tables 34 & 35, 2012-2027 Projected Energy Efficiency Program Schedule; SRP, FY 2013 EE Report.

Achieving these goals and reaping the benefits of energy efficiency for the state's economy will require full support of public policies and programs along with further initiatives from local and state leaders. The GOEP is committed to further educating the public about the benefits of energy efficiency and once the tasks outlined in *emPOWER Arizona* are implemented, state agencies, school districts and local governments will have access to vetted and reputable contractors to move toward increased energy efficiency in public buildings.

WATER

Current Status

Water and energy have traditionally been addressed as two separate issues. However, water and energy are inextricably linked and sustainable management of either resource requires consideration of the other. Water and energy are critical, mutually dependent resources because the production of energy requires large volumes of water and water infrastructure requires large amounts of energy. In the U.S., the electricity industry is second only to agriculture as the largest water user.

According to the National Renewable Energy Lab (NREL), electricity production from traditional energy resources requires 190,000 million gallons of water per day, which accounts for 39 percent of all withdrawals nationwide. Energy generation is needed to extract, convey, treat, and deliver potable water and, once used by the consumer, energy is then required to collect, treat, and dispose of wastewater. According to the DOE, approximately 4 percent of U.S. power generation is used for water supply and treatment. In other words, about 75 percent of the cost of municipal water processing and distribution is electricity.

Hoover Dam, once known as Boulder Dam, is a concrete arch-gravity dam in the Black Canyon of the Colorado River, on the border between the US states of Arizona and Nevada. It was constructed between 1931 and 1936.

Three states within the Mountain West (Arizona, Colorado and Nevada) have enacted laws that recognize the nexus between water and energy. Arizona and Nevada have statutes that mention the appropriation of water for electric generation. By passing these statutes, Arizona has established water conservation and augmentation measures to ensure that water and energy needs are met, particularly as the population increases over the next decade.

Challenges

To sustain energy production and a dependable water supply, Arizona must:

- Have a detailed understanding of the interdependencies of water and energy systems.
- Balance the needs of all users.
- Develop technologies to reduce water use.

These goals can be achieved through:

- Public education.
- Scientific and technological innovation.
- Implementation of low- or no-use water technologies.

Most Arizonans are unaware that approximately 9.5 percent of Arizona's total electricity production is spent treating, transporting, and using water. In general, 7.85 gallons of water evaporate for every kilowatt-hour (kWh) consumed.

The average electrical use per household in Arizona was 11,061 kWh (in 2009) equating to just under 87,000 gallons of water use per year; this does not include the energy cost per household to provide safe, clean and abundant drinking water nor does it include the cost of water for showering, landscaping, washing clothes etc.

The GOEP has committed to educate Arizonans, specifically water/wastewater facility owners and operators, about energy- and water-savings opportunities. In 2013, the GOEP worked with nine agencies and organizations to obtain funding from a DOE State Energy Program (SEP) competitive grant to identify energy-efficiency needs at Arizona's water and wastewater facilities.

Arizona is one of two states (Rhode Island is the other) to receive this funding focusing on the water-energy nexus. The goal of the Water Energy Partnership in Arizona (WEPA) is to benchmark energy usage at 100 wastewater facilities, direct these facilities to funding opportunities, and promote energy-efficiency measures for wastewater utilities. Relevant benchmarking data will be used to educate policy makers and the general public about the inherent benefits of reducing energy use when treating wastewater, especially as Arizona continues to grow.

The state's explosive population growth from year-to-year led to a rapidly increasing demand for energy, and as the demand for electricity increases, the demand for water resources also increases. A water shortage can limit power generation and increase electricity prices paid by consumers. Most electric-generation processes consume large amounts of water.[46] As an illustration, the largest coal plant in Arizona, the Navajo Generating Station (NGS), a 2,250 MW facility, uses approximately 24,000 acre feet (7.8 billion gallons) of water in a year.[47] The largest natural gas plant, Arizona's Gila River Power Station (a 2,200 MW facility), uses 4,600 acre feet (1.5 billion gallons) of water in a year.[48] The Palo Verde Nuclear Generating Station (PVNGS) (3,739 megawatt facility) uses about 61,400 acre feet (20 billion gallons) per year[49] [50] and is the only nuclear plant in the world that singularly uses reclaimed wastewater for cooling.[51]

A method to significantly reduce water usage in thermal electrical generating facilities is the dry-cooling technique. A thermal plant, like the example below, is one which operates by using heat to add energy to a working fluid, which is then converted to electricity through a mechanical system, such as a turbine. Such plants operate on the Carnot Cycle and must obey the equations governing the cycle. Typically, the best efficiency that can be attained in practice and at reasonable cost is approximately 50 percent. What this means is after putting in 1,000 units of fuel, the best expectation is for 500 units of electrical output. The other 500 units is waste heat, a byproduct of the process cycle.

The most efficient way to remove waste heat is through thermal cooling. In Arizona, there are cases where dry-cooling technologies have been deployed or are under development. Dry cooling consists of using huge fans to blow large quantities of ambient air across the equipment. But these fans consume a significant portion of the power generated by the plant itself and they don't cool the system as effectively as water.

The end result is much lower operating efficiency, meaning less units of electrical energy out for a given amount of fuel. As of today, there are few dry-cooled electrical plants in Arizona due to its current economic viability.

10-Year Outlook

Since the 1980s, nighttime temperatures in the Phoenix and Tucson areas have increased due to many factors, including rapid urbanization and expansion, and possible, yet disputable climate changes. This will affect Arizona's water-energy nexus in the future in the following ways:

- This increase in nighttime temperatures impacts Arizona's "peak load," specifically in urban areas such as Phoenix and Tucson. As the nighttime temperatures have increased, the "peak load" time frame has increased in conjunction with the use of air conditioning throughout the evening.
- In Arizona, 25 percent of the energy consumed in homes is for air conditioning, which is more than four times the national average of 6 percent. These numbers could climb if nighttime temperatures continue to increase, thereby requiring more generation and more water.
- Due to the projected population growth and the increase in nighttime temperatures, new generation facilities may be needed to keep up with demand.

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3. LAND OWNERSHIP AND USE

Arizona's surface area is approximately 72.9 million acres of land (113,417 square miles) and is the sixth largest in the United States. Major landowners in the state are:

- The federal government which is the largest land owner with 42 percent.
- Tribes which own 28 percent.
- Private land owners which account for 17 percent.
- The State Trust which owns 13 percent.

While many large governmental holdings are in the far reaches of the state, much of the population and private ownership is centralized in urban areas.

The United States Census Bureau estimates Arizona's population in 2013 was 6,626,624, which ranked the state 15th nationwide. Its density of 57 people per square mile makes the state the 33rd densest. Although the density of persons per square mile is below the national average, the majority (82 percent) of Arizonans live in incorporated cities and towns, specifically in the Phoenix and Tucson metropolitan regions, making Arizona a more urban than rural state.

As urban areas develop and expand, they displace agricultural lands and encroach upon military installations and electrical generators as well as transmission lines, and create challenges for siting and locating central station generation and transmission lines. Urban expansion creates concerns relative to job reliability and growth in those industries. Therefore, developers are now looking to public lands to address the impact of continued development of urban, private lands.

FEDERAL LANDS

Current Status

Arizona's federal land ownership primarily consists of the Bureau of Land Management (BLM), United States Forest Service (USFS), National Park Service, Fish and Wildlife Service (USFWS), and the military. The management and development of the land for the public's use and benefit are under the purview of each agency for its respective purposes.

BLM Arizona administers 12.2 million surface acres of public lands, along with another 17.5 million subsurface acres. The state's nine land management areas are:

- Arizona Strip
- Grand Canyon-Parashant National Monument
- Hassayampa
- Kingman
- Lake Havasu
- Lower Sonoran
- Safford
- Tucson
- Yuma

The USFS administers approximately 11.25 million acres of Arizona's land, ranging in elevations from 1,300 feet to over 12,000 feet and encompassing 28 wilderness areas and the Tonto National Forest, one of the nation's top 10 most-visited forests. Arizona's six designated National Forests are:

- Apache-Sitgreaves
- Coconino
- Coronado
- Kaibab
- Prescott
- Tonto

The National Parks Service system in Arizona includes Grand Canyon National Park, Saguaro National Park, Petrified Forest National Park and 19 other national monuments, memorials, recreation areas, historic sites and trails.

The USFWS administers approximately 840,000 acres of land encompassing Arizona's eight national wildlife refuges:

- Bill Williams River
- Buenos Aires
- Cabeza Prieta
- Cibola National
- Imperial
- Kofa
- Leslie Canyon
- San Bernardino

Challenges

The Arizona federal land management agencies, primarily the BLM, approved utility scale renewable energy and transmission projects from 2007 to 2013. The time frames for wind and solar project permits ranged from one and a half to four years from receipt of the initial application to project approval.

To address the time-frame issues, BLM Arizona developed the Restoration Design Energy Project (RDEP), which identified lands across the state that might be suitable for developing renewable energy. The RDEP identified 192,100 acres of Renewable Energy Development Areas (REDAs) on BLM lands throughout Arizona, specifying federal lands suitable for solar development. However, the identified federal lands suitable for solar development indicated in the RDEP are miles from existing transmission, making them potentially impractical due to the costs associated with interconnection of transmission. The RDEP also does not eliminate the need for further environmental review of individual sites and requires formal National Environmental Policy Act (NEPA) processes, which add time, cost and risk to developing on BLM-administered lands.

The above issues complicate transmission development on BLM lands. Since most central station generation is located outside urban areas, the transmission to urban areas requires traversing federal, specifically BLM, lands. Due to the environmental processes, transmission permitting takes several years and causes utilities and private developers to endure hefty upfront development costs and excessive review time frames, with little assurance that such costs will be recouped. This not only applies to in-state transmission but transmission to neighboring markets, thus decreasing the potential for development on these lands.

10-Year Outlook

Energy infrastructure development (e.g., generation and transmission) on federal lands in Arizona are confined to BLM lands. For the most part, National Parks, Forest Service, and national refuge lands are undevelopable due to federal regulations. However, there are certain ways which these lands can and will participate. One example is the Four Forest Restoration Initiative which is designed to restore fire-adapted ecosystems in the Kaibab, Coconino, Apache-Sitgreaves and Tonto Forests. Through this initiative, the thinning of forests could provide extra fuel for biomass electrical production in Arizona.

Energy infrastructure development will be most prevalent on BLM lands. Among those initiatives are modifying the RDEP, which redesignated acceptable lands for renewable energy development to include potential lands which were originally omitted. The federal government also attempted to designate energy corridors for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities. The designation is still under litigation and a final decision is pending.

Due to the complexity of developing federal lands, most energy infrastructure activity will continue on the ample amount of developable state and private land. However, as population and subsequent load growth increases, federal lands will likely be needed for infrastructure expansion, infrastructure co-location and new corridor development.

STATE TRUST LANDS

Current Status

The Arizona State Land Department (ASLD) oversees approximately 9.2 million acres of land which is held in trust and managed for the sole purpose of generating revenues for 13 beneficiaries, the largest of which is Arizona's K-12 education system. The trust generates revenues through the sale and lease of lands for grazing, agriculture, municipal, school site, residential, commercial and open-space purposes.

The energy sector is now starting to utilize state lands for energy development. As of 2013, Arizona has seven renewable-energy generation projects located on State Trust lands. Three examples of these are:

- In March 2012, ASLD entered into its first agreement to develop solar on state lands with APS, the 35 MW Foothills Photovoltaic Solar Plant near Yuma.
- The Arlington Valley Solar Energy II, located west of Buckeye, develops solar energy on ASLD lands.
- The Dry Lake Wind Power Project, located near Heber, produces power for SRP customers and is the state's first commercial-scale wind farm situated on ASLD, private, and BLM lands.

Challenges

Energy development on trust lands faces two primary challenges, both relating to regulation:

- Conflicts arising from multiple jurisdictions having separate objectives for the same land resources.
- Optimizing the processes for leasing and selling land in Arizona to meet the needs of future development, e.g., standardized renewable-energy leasing agreements.

10-Year Outlook

Two major changes regarding State Trust lands are the expansion of the definition of agricultural lands and the development of mapping resources for energy policymakers and developers. In 2012, the definition of "agricultural lands" was expanded to include "algaculture," the cultivation of algae which is an emerging biofuel source. In the future, ASLD will be able to lease land to grow and develop this potential fuel source.

The ASLD, in conjunction with the GOEP has developed the Arizona Solar Energy Viewer to identify and promote state lands that are best utilized for solar development and a Solar Land Lease, which helps to create a standardized mechanism relative to leasing by developers as mentioned in the Executive Summary these efforts are being expanded. These developments could benefit private development and encourage new leases benefiting K-12 education in Arizona.

PRIVATE LANDS

Current Status

Development of energy resources and efficiencies on private lands and buildings constitutes the majority of energy development in Arizona. Energy efficiency, distributed generation, central station generation resources, transmission and pipeline projects differ in the ways and methods to develop them on private property. Arizona is a "Home Rule State," there are conceivably 107 different ways to permit energy projects throughout the state's 92 municipalities and 15 counties.

Market realities and recently implemented environmental policies have brought the real estate industry to a pivotal point. Land use decisions are as much about the management and redevelopment of existing real estate as they are about the development of new buildings, collocation of transmission and pipelines and clustering generation resources.

Challenges

Land use, real estate development and energy are inextricably connected to current patterns and future trends in transportation and the economy. Viewing it all through a holistic lens will ultimately be necessary to ensure success in developing federal, state and local policies and innovative private business practices. Zeroing in on the relationship of energy to land use and real estate development, a variety of issues become clear:

- Energy consumption related to building efficiency.
- Renewable energy opportunities for new development
- Energy capacity to support infill development.
- Energy generation to meet the needs of the future populations.
- Creation of a regulatory environment that supports land use and development
- Investment to promote healthy, sustainable communities.

Local, state, and regional levels of government have been the platform where markets are being shaped to align intended environmental outcomes with an economic development strategy. But today, a changing regulatory environment is shaping energy investments in real estate and creating a lack of predictability and certainty.

In order to enhance energy investments, both new tools and new rules will have to overcome market barriers that prevent strategic energy-efficiency investments in the existing building stock and large-scale energy developments, such as central-station generation.

Challenges related to transmission, pipeline and generation development can be attributed to Arizona's checkerboard landscape of federal, state, tribal and private ownership. In the case of private ownership, these challenges manifest themselves in the sheer number of private land owners, parcels and so forth. The negotiations over just compensation for easements, the prevalence of NIMBYism (Not In My Back Yard) and the eminent domain processes related to those entities which have authority, all create a myriad of complex issues related to energy efficiency and distributed generation, the siting of transmission, pipelines and other generation projects.

10-Year Outlook

Development of energy resources is complicated, expensive and often divisive. Some groups oppose many forms of energy development; other groups and individuals would prefer federal, state, and local regulations be streamlined. However, there are groups working to propose compromises to resolve regulatory concerns and assure consistency in permitting time frames and regulations.

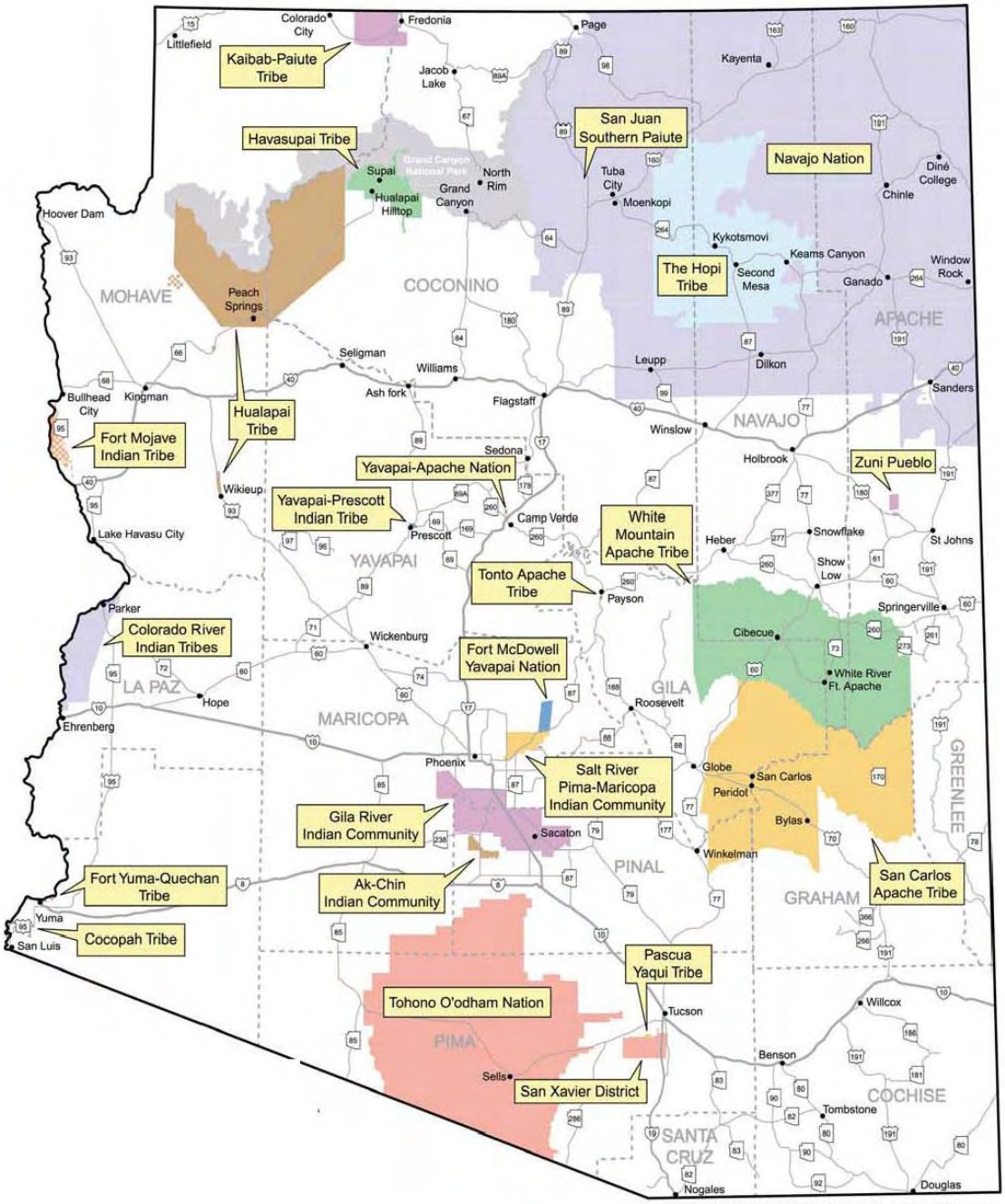
Investors need information on the market value of energy efficiency in order to understand the opportunity cost. Standardization of benefits would make improvements scalable across the marketplace, and market-specific performance data can make investments bankable. Currently, the only dedicated capital remains in government and utility incentives, and these are not adequate to catalyze the marketplace.

As previously noted, Arizona is a Home Rule State; therefore, regulatory entities are starting to realize the benefits of sharing best practices. As part of Governor Brewer's Solar Energy Advisory Task Force, best practices related to residential and commercial permitting and policies have been identified and promoted. Localities wishing to capture economic development benefits related to energy development are implementing these best practices.

Additionally, a number of new energy efficiency financing models have emerged, including Energy Service Agreements (ESAs), utility on-bill repayment, and Property Assessed Clean Energy (PACE). Nationwide, 31 states and the District of Columbia have PACE-enabling legislation in place; some of these programs have shown early successes. PACE programs advance energy-efficiency improvements in the market because they provide validation of common technologies and improvement measures. Although PACE has been discussed in Arizona, there is not a program in place at this time.

TRIBAL LANDS

Current Status



Tribal governments play a critical role in the production and distribution of energy in Arizona and throughout the West. In fact, almost all of the mineral-based energy resources within Arizona, particularly coal, are on tribal lands. The above map identifies 22 federally recognized Indian Tribes of Arizona. The Hopi and Navajo lands in the Black Mesa area hold the largest coal deposits in the United States, with approximately 21 billion tons of coal and a long-term value as high as $100 billion.

The 2,250 MW Navajo Generating Station (NGS) on the Navajo Nation is the second largest power plant in Arizona. Tribal lands also contain numerous natural gas pipeline segments, transmission lines for electricity and hydroelectric dams.

In addition, in 2013 the Navajo Nation approved a new tribal energy policy[52], formed the Navajo Transitional Energy Company for possible acquisition of the BHP Navajo Mine[53] and completed a feasibility study for 4,000 MW Solar Power at Paragon-Bisti Ranch[54].

Other tribes in the process of developing renewable energy projects are the Hualapai Tribe of Peach Springs, Pasqua Yaqui Tribe in Tucson, San Carlos Apache Tribe (San Carlos, AZ) and the Gila River Indian Community in Sacaton[55].

Challenges

Although tribal governments are sovereign nations, facilities on their lands are affected by federal energy laws and policies that have evolved over the past century, a number of which were specifically enacted to control energy resources on tribal lands. New requirements for regulation of emissions imposed under laws, specifically by the Clean Air Act, impact the future of coal-fired plants such as the NGS. Additional emission-control technology will require substantial investment by the utilities that own the plant, and the tribes have expressed concerns about the costs of the most pollutant-reducing technologies proposed by EPA.

Given both the Hopi Tribe's and the Navajo Nation's significant economic reliance on revenues associated with the plant, any plant closure poses a serious threat. The specific threat to NGS, however, is being mitigated by Salt River Project (SRP) and the Navajo Nation's other associated partners. The issue of plant closure is also a critical reason to develop a diverse and stable energy mix to ensure at least one source of base-load energy is always available to avoid energy shortfalls.

10-Year Outlook

Arizona's tribal governments are developing partnerships to pursue larger-scale development of their significant solar, wind, and biomass resources. In addition, tribal governments are making significant use of on-site renewable energy (particularly solar panels) for homes as well as public buildings and facilities.

At the same time, tribal governments are seeking greater ownership and control over mining, power plant, and transmission line projects on their lands.

AGRICULTURAL LANDS

Current Status

Agriculture in Arizona is a $9.2 billion industry. As an agricultural hub, Arizona:

- has more than 15,000 farms and 26.1 million acres in cultivation;
- ranks second in the nation in production of cantaloupe and honeydew melons, head and leaf lettuce (Yuma is considered the winter lettuce capital of the world), spinach, broccoli, cauliflower and lemons; and
- yields 8.3 million tons per acre of alfalfa, more than the national average of 3.4 tons per acre.

Arizona is also well-known for ranches and dairies with approximately one million head of cattle and calves producing 386 million pounds of beef annually, and with 186,000 dairy cows producing 23,382 pounds of milk per cow.

Solar power irrigation systems are being deployed in Arizona through grants from the Rural Energy for America Program, part of the U.S. Department of Agriculture. The solar grants were announced in September 2013. This could help Arizona cattlemen, dairymen, and growers become more independent from traditional fuel for their water systems. (Photo courtesy of Roxanne Knight and the Arizona Cattle Growers' Association)

Between 2009 and 2012, the Governor's Office of Energy Policy (GOEP) received federal funds totaling $916,538 leveraged with $471,336 from farmers and ranchers. These funds, totaling $1,387,874, were used to install 51 renewable energy systems on 41 ranches and farms. These systems replaced gasoline and diesel generators used to pump water for livestock, crops and

fruit trees. The renewable energy systems have 15-year lifespans with an estimated savings of $316,495 per year; cumulative savings over 15 years could total more than $4.7 million. Additional savings will be realized as these projects eliminate the need to deliver gasoline or diesel to remote areas.

In its 2012 final report, the Arizona Natural Resource Conservation Districts (AZNRCD) complimented the successful use of the funds: "Fossil fuel systems were replaced with wind and solar-generated energy for irrigation systems, greenhouses, water-pumping systems for livestock, and power for 'ag' structures critical to the production unit. It is safe to assume that without this program these systems would not have been replaced because the return is not immediate and, in this economy most farms and ranches would not be able to afford such a conversion even though it pays off in the long term."

In addition to the benefits for individual agricultural producers, these projects serve as best-practice models that can be shared with agricultural producers throughout the state, particularly where well-water pumping is needed or grid electricity is not available. Using knowledge gained from the success of these efforts, the Arizona Department of Agriculture and the GOEP are partnering to conduct energy audits of dairies and farms. The goal is to identify opportunities where renewable energy systems would make economic sense.

In March 2013, the ADA's Agriculture Consultation and Training (ACT) renewed its partnership with AZNRCD to provide free energy audits; outreach and education efforts to agriculture producers included:

- Making 87 on-site visits to local producers to promote the audit program, explain its benefits, discuss the steps involved in the audit process, and identify what will be expected from the producers.
- Promoting the program at various agricultural industry functions and meetings, including the local and State Farm Bureaus, Arizona Nursery Association, United Dairymen of Arizona, and local Natural Resources Conservation Districts. These 20 promotions reached 2,629 participants.

The promotions resulted in conducting 26 audits and issuing a final report that included information on current energy use, recommendations to increase the facilities' energy efficiency, and possible cost-share programs available to help implement the recommendations.

Arizona farmers and ranchers have also received federal funding from programs such as the United States Department of Agriculture (USDA) Rural Energy for America Program (REAP), which provides assistance to agricultural producers and rural small businesses to complete a variety of projects. REAP offers both loan guarantees and grants to help eligible applicants install renewable energy systems, make energy-efficiency improvements such as installing irrigation pumps or replacing ventilation systems, and conduct energy audits and feasibility studies. As one example, in 2011, an Elfrida farming operation used a $49,975 REAP grant to

help install photovoltaic water pumps. The REAP grant covered about a quarter of the cost of the new photovoltaic system with the farmer covering the rest; the new system cut utility bills in half.

Challenges

The agricultural industry faces multiple challenges including:

- Remoteness of operations.
- Increasing energy costs.
- Decreasing return on investment for agricultural operations.
- Encroachment of urbanized areas.
- An aging workforce.

As with many other industries, agriculture must embrace technology and innovation in the energy sector to grow and maintain profitability. Although the ADA and the GOEP have taken positive steps, their partnership must continue to evolve and foster energy and energy-efficiency solutions for the agriculture industry.

10-Year Outlook

Agriculture will continue to be a thriving industry in Arizona. Energy related to the agricultural industry will continue to evolve through energy audits, agriculture technological improvements, implementation of renewable-energy systems designed and installed for water harvesting on remote ranches, and improved transportation of product to market. The ADA-GOEP partnership is critical in this evolution as it identifies funding opportunities for efficiency, renewable energy systems and transportation fuel choice.

MINING LANDS

Current Status

Arizona has a long history of mining operations related to gold, silver and particularly copper. These operations, predominately located in the furthest reaches of the state, require massive amounts of energy. Due to these remote locations, mining owners developed their own electrical utilities to service the mine operations and also created “company towns” like Ajo. As mining operations have become more complex, the need for energy has increased and new energy efficiencies are being implemented. This has caused operations to become more mechanized and the byproduct of this activity is high-paying jobs for rural Arizona in both the mining and energy sectors. The efficiencies of mining operations have followed suit.

For communities such as the Globe-Miami and Morenci-Clifton areas, mining operations are still the largest employer. In other cases, where mine closures have occurred, the towns have experienced both negative and positive effects: Jerome and Bisbee rebranded themselves as tourist destinations; Crown King and Castle Dome became ghost towns.

In the energy sector, some mining companies are repurposing areas in which mine tailings (mine waste products) are located as potential renewable energy development locations. Some of these companies are utilizing these areas for renewable energy projects since they are now unable to use the locations for any other purpose.

Challenges

The mining industry faces obstacles, such as:

- Commodities' market volatility.
- Foreign competition.
- Increasing energy costs.
- Increasing environmental regulations.

Moratoriums on uranium and other hard-rock mining in northern Arizona have compounded these issues. In January 2012, then Interior Secretary Ken Salazar signed a mining moratorium on 355,874 acres of U.S. Forest Service land in the Kaibab National Forest, 626,678 acres of BLM land, and 23,993 acres of split estate where surface land is owned by one entity and the subsurface minerals are owned by another, in this case the federal government. Governor Brewer stated her opposition to this measure: "The 20-year ban comes at the expense of hundreds of high-paying jobs and approximately $10 billion worth of activity for the Arizona economy."

10-Year Outlook

According to the 2013 Deloitte Report, *Tracking the Trends: 2013 Top 10 issues mining companies may face,* the availability of key resources such as energy is the number one concern. As mining companies move away from energy infrastructure to increasingly remote regions, energy costs will increase due to transmission and transportation needs.

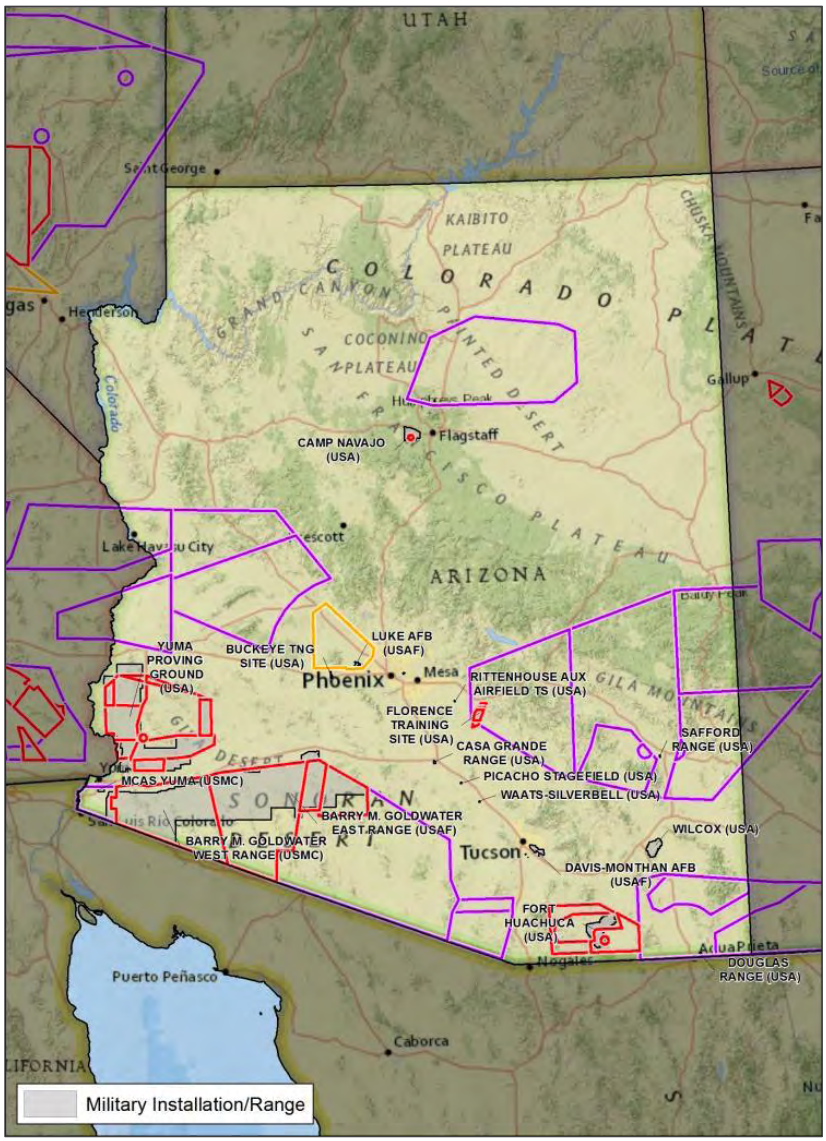
Mining companies will continue to look at new income sources relative to lands which are environmentally unsuitable for development, but which may also be suitable for renewable-energy development, in order to create income and diversify the economic portfolio of their operations.

MILITARY LANDS

Current Status

Arizona's history with U.S. military installations dates back to the 1851 establishment of Fort Defiance. Over the years, the state's relationship with the U.S. military has grown; additional military installations include:

- AZ Air National Guard, 161st ARW
- AZ Air National Guard, 162nd FW
- Barry M. Goldwater Range (USMC and USAF)
- Camp Navajo Army Depot
- Davis-Monthan Air Force Base
- Florence National Guard Target Range
- Fort Huachuca Army Base
- Gila Bend Air Force Auxiliary Airfield
- Luke Air Force Base
- Luke AFB - Auxiliary Field #1
- MCAS Yuma - Auxiliary Field #2
- Silverbell Army Heliport
- Papago Park Military Reservation
- U.S. Marine Corps Air Station, Yuma
- U.S. Naval Observatory Station, Flagstaff
- Yuma Proving Grounds, Yuma Test Range



According to a 2008 Arizona Department of Commerce report conducted by the Maguire Company and ESI Corporation, the overall economic impact of the military in Arizona is approximately $9 billion a year.

Overall, the U.S. Department of Defense's (DOD) annual energy bill is approximately $4 billion, which reflects the large footprint of managing over 500 U.S. and overseas installations, consisting of nearly 300,000 buildings covering 2.3 billion square feet of building space.

In addition to their costs, these installations are largely dependent on a commercial power grid that is vulnerable to disruption due to aging infrastructure, weather-related events and a potential kinetic or cyber-attack.

In 2012, the DOD mandated that military installations become energy independent to reduce both threats to disruption and costs. The DOD's goal is to build three gigawatts of renewable energy on military installations by 2025.

In 2014, Arizona's military installations have expanded their renewable energy portfolio with a 14.5 MW photovoltaic solar array covering 130 acres at Davis-Monthan Air Force Base in Tucson, and an 18 MW photovoltaic project, currently under construction on 68 acres at the Army's Fort Huachuca in Sierra Vista, which will be one of the largest in the country.

In addition, Luke Air Force Base in Phoenix has entered into exclusive negotiations to lease property (106 acres) for a future solar generation project.

All solar projects are coordinated through local utilities and after construction, are maintained and operated by them. For example, the Army and Tucson Electric Power entered into a 30-year easement to facilitate the Fort Huachuca solar project. The Army has identified a 155-acre parcel of land for solar development.

It is interesting to note that Davis-Monthan Air Force Base is home to one of the largest community-based photovoltaic arrays in the Continental U.S., supplying 75 percent of electric usage to more than 200 new homes for base housing.

The Governor's Office of Energy Policy was a member of the 2014 Strategic Military Affairs Advisory Panel which toured military bases around Arizona and contributed their time and energy expertise to a final report submitted in response to Governor Jan Brewer's Executive Order 2014-02, Sustainment of Arizona's Military Installations.

Challenges

As noted, military installations rely on commercial grids, which are vulnerable to natural or manmade disruptions that have the potential to create short- or long-term power outages impacting military installations and their ability to sustain missions.

Appropriations relative to direct funding of operations, maintenance and energy have been relatively low in the recent years due to sequestration and other issues.

Congressional appropriations amounting to just under $1 billion funded 1,436 energy-efficiency, renewable-energy, and water-conservation projects, according to the 2012 DOD Annual Energy Management Report. This is a significant increase from last year's $600 million funding for 873 energy-related projects. DOD's fixed installations account for approximately 25 percent of its total energy use.

Photo courtesy of Davis Monthan AFB

Davis Monthan Air Force Base has implemented solar on its land and it's most impressive undertaking is the 14.5 MW solar PV project. This facility covers 130 acres of land at two locations on the base and is expected to provide approximately 35 percent of the base electricity requirements, reducing base utilities cost by an average of $500,000 annually.

10-Year Outlook

DOD is pursuing a multi-pronged strategy to ensure that installations:

- Reduce energy demand through energy-efficient facilities and behavior-based conservation;
- Expand the supply of renewable energy;
- Enhance the energy security of DOD installations; and
- Leverage investment toward the development of advanced energy technologies.

Investments in technology are focused on the development, demonstration, and deployment of next-generation microgrids that offer a direct, robust and cost-effective approach to ensuring installation energy security.

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4. MOVING POWER

Energy powers the lives of people: moving them to and from home to work by personal vehicle or public transportation; providing heating, cooling and lighting for a home or office; or enabling entertainment activities like movies and television.

People may never consider what these actions entail: transporting fuel from where it is extracted to its point of sale or moving a turbine to generate a current that is carried over many miles of high-voltage wires to a transformer that reduces its voltage, enabling it to be used safely in homes and businesses.

Utilities daily provide these enormously complex undertakings for their customers.

TRANSPORTATION

Current Status

Access to reliable and affordable transportation options is a critical piece of securing Arizona's economic future. A well-functioning system of highways, public transit, airports, railways, and pipelines is needed to support commerce. Although gasoline and other fuel prices in Arizona tend to be lower than the national average, transportation remains a significant household expense. Therefore, finding ways to make transportation more cost-efficient will benefit Arizona.

Arizona's transportation sector is fueled almost entirely by petroleum products, delivered by a large pipeline infrastructure. Because Arizona has no crude oil supply or refining capacity, it must import all its petroleum-based fuel and rely on commodity markets for supply and price. The cost of supplying this fuel is estimated at $12.5 billion annually,[56] with the bulk of these expenditures leaving the state.[57]

In Arizona, transportation fuel is predominately consumed by light-duty vehicles (e.g., cars), although heavy-duty vehicles (e.g., trucks) and airplanes also comprise significant shares.[58] The bulk of these vehicles rely on petroleum-based fuels; however, there is a small but increasing share of the vehicle fleet that relies on alternative fuel sources such as compressed natural gas and electricity.[59] Natural gas is gaining traction due to the abundance of new supplies available from shale gas resources. However, Arizona has virtually no natural gas reserves and will also be dependent on out-of-state resources for natural gas vehicles.

Arizona has already adopted a number of policies that support EVs and EV-charging stations, the state:

- Offers a $75 tax credit for the installation of an EV-charging outlet in an individual's home.

- Provides EVs with special plates from the Arizona Department of Transportation (ADOT) for use of High-Occupancy Vehicle (HOV) lanes.
- Allows EVs to park in spaces designated for carpool vehicles.
- Lowers annual vehicle license taxes for EVs below those of a conventional gasoline vehicle.
- In the Phoenix and Tucson metro areas, EVs are exempt from the emissions-testing program.

Public transportation is a viable option for commuting in urban areas and, due to new technologies being developed, Arizona fleets are saving money and preserving our environment's beauty.

The city of Phoenix purchased 120 Valley Metro buses fueled by Compressed Natural Gas (CNG). This is projected to save the city $4 million dollars. Sun Tran in the city of Tucson has 46 CNG buses deployed in its fleet as well.

CNG emits fewer regulated gases than other traditional fuels and is powerful enough to move large amounts of freight and people.

Challenges

Maintaining the health and efficacy of Arizona's transportation system presents significant challenges. As vehicles become more efficient and alternative fuels become more prevalent, the gas tax that the public relies on to build and maintain transportation infrastructure diminishes.

A more efficient vehicle fleet impacts the traditional system of collecting and distributing funds that support transportation infrastructure. The excise tax on gasoline and diesel fuel is a primary source of revenue for state and federal highway construction, improvement, and maintenance projects.

As vehicle technologies improve and travel demand declines as our population growth slows, petroleum tax revenues decrease. As a result, Arizona faces a potential crisis in terms of providing sufficient transportation infrastructure funding.

Another revenue issue is that because EVs do not use gasoline, they contribute significantly less than traditional vehicles to the state's Highway User Revenue Fund (HURF), over half of which is funded by gasoline taxes. As EVs become more numerous, an additional method of collecting revenue will be needed to ensure that EVs contribute to construction, maintenance and repair costs of the roads they share.

Currently, Arizona collects taxes per gallon on gasoline and diesel fuel. These tax revenues are deposited into the state HURF and distributed to the State Highway Fund as well as to cities, towns, and counties. The federal government collects taxes on gasoline and diesel fuel which is deposited into the federal Highway Trust Fund where they are distributed to federal, state, and local governments for highways, bridges, roads, and transit projects. The Arizona tax has not increased since 1991 and the federal tax has not increased since 1993. Many contend that this presents transportation infrastructure funding challenges, as system demands outpace current investment receipts and jeopardize necessary maintenance and expansion.

The U.S. Congressional Budget Office (CBO) reports that since 2008, more than $41 billion has been transferred from the General Fund to the federal Highway Trust Fund; $12 billion is authorized in 2014; and an additional $15 billion will be needed in 2015. By 2022, the CBO projects that alternative-fuel vehicles will reduce federal Highway Trust Fund gasoline and diesel fuel tax receipts by 21 percent, roughly $57 billion. Other states have explored remedies such as changing gas taxes, toll roads, alternate fuel assessments, local taxation programs, tire fees, and mileage charges.

The state and national revenue shortfall challenge should be addressed not only through reforms, but also by a close examination of existing policies for spending on transportation infrastructure.

Infrastructure development is needed to facilitate the transition to more fuel-efficient and alternative-fuels vehicles. There are currently 15 light-duty electric vehicles (EVs) available from large-scale vehicle manufacturers, including plug-in hybrid electric vehicles (PHEVs), with seven more models expected by 2014. EV sales continue to increase, with nationwide sales through August of 2013 already outpacing sales for all of 2012. One initiative to address this growing market segment is the deployment of EV-charging stations. Consumers should know the alternative fuel supply and distribution network to be reliable in terms of redundancy and security.

Arizona currently has 366 alternative fueling stations with 264 if those being EV-charging stations. In anticipation of integrating more electric vehicles into the grid, the state's three largest utilities – SRP, APS and TEP – all offer special Time of Use Rates for EV charging, giving EV owners an additional way to save on fuel costs.

This can make faster payback periods for EVs possible and reduce the need EVs might have during peak demand. Due to the solid foundation of residential charging infrastructure, Arizona is well-situated to increase the adoption of EVs and take advantage of the benefits they offer.

However, currently almost all of the publicly available stations are concentrated in urban areas, making it difficult for EV drivers to make long-distance in-state and out-of-state trips. A DC fast charger[56] was recently installed between Phoenix and Tucson to facilitate travel between those two cities, but without additional charging stations along major highway corridors and at additional destinations, EVs will remain largely limited to urban areas.

10-Year Outlook

After electrical generation, transportation is the state's second largest end-use of energy, comprising about a third of total energy consumption.[60] Arizona's demand for transportation energy has historically grown alongside its population. However, this growth trend has reversed and travel demand has slowed in recent years. Going forward, a number of changes to Arizona's transportation sector can be anticipated. One of the most significant will be the fuel efficiency of vehicles.

Vehicle fleets have recently increased their fuel efficiency, in large part because of the U.S. Department of Transportation's Corporate Average Fuel Economy (CAFE) standards. Between 1990 and 2007, CAFE standards were unchanged for automobiles. However, in 2010, final standards were issued for model years (MY) 2012 through 2016. In 2012, final standards were issued for MY 2017 through 2021 and proposed standards for MY 2022 through 2025 were made available for public review. The established standards in 2016 are anticipated to be 34.1 miles per gallon (MPG) and are expected to rise to 49.6 MPG by 2025.

The drawback to CAFE standards is the projected loss of revenue for the Highway Trust Fund. By 2023, the CBO projects that the cumulative shortfall in the federal Highway Trust Fund will be over $120 billion. As newer automobiles become more fuel-efficient and switch to alternative fuels, the need to create sustainable transportation funding sources will only grow. Automobile manufacturers and parts suppliers will need to develop and innovate technologies to meet new CAFE standards, whereas local, regional, state, and federal transportation leaders will need to identify new and innovative opportunities to create sustainable revenue sources for providing, maintaining, and improving integrated and multimodal transportation networks.

The relative importance of freight transportation within the economy will continue to grow amidst concerns for safety, economic efficiency, and environmental sustainability. Trucks transport about 68.5% tonnage carried by all modes of domestic freight transportation, including manufactured and retail goods in the United States. However, it is important that future policy impacting freight transportation reflect its vital importance in domestic and international economies. For instance, stricter air quality standards are likely to be enacted by the EPA and thus influence transportation policy, planning, and priorities.

PIPELINE INFRASTRUCTURE

Current Status

Refined petroleum and natural gas fuels are delivered through a limited number of interstate pipelines, mostly owned by Kinder Morgan. These pipelines deliver refined petroleum products and natural gas to Arizona's metropolitan areas and rural communities which is then distributed by third-parties, such as Southwest Gas, to consumers. Arizona generally has good fuel accessibility in its rural communities, although improved monitoring and tracking could improve this distribution. This traditional fuel supply and the traditional fuel delivery infrastructure have been adequate for meeting Arizona's needs.

However, uncertainties exist in the future market dynamics for transportation fuels – particularly the role of natural gas – that may give rise to new infrastructure needs.

For instance, electric utilities are expected to rely increasingly on natural gas as EPA regulations put additional pressure on coal power plants, thereby increasing the need for new gas delivery and storage infrastructure (e.g., compressor stations, salt domes, etc.).

As new fuel needs arise from changing market conditions, it is less likely that new pipelines will be constructed in favor of existing pipeline conversions. As such, Arizona's fuel delivery infrastructure needs should be periodically reassessed to account for any changes in demand, particularly those driven by electric generation or fleet fueling-station needs.

Challenges

Despite the current adequacy of Arizona's fuel delivery infrastructure, some of its aging pipelines present concerns regarding the physical and cyber-security of the fuel supply. Improving the security and redundancy of our transportation fuel infrastructure presents a challenge to the state that is expected to become more pronounced in the next 10 years and will require careful monitoring.

Additional factors to the fuel supply might include uncertainties in the affordability and availability of traditional fuel blends, and use of natural gas for renewable energy integration.

10-Year Outlook

A 10-year evaluation timeline may be inadequate to assess future transportation infrastructure needs. In particular, fuel storage infrastructure has been identified as one of Arizona's potential long-term needs, and exploring options to increase fuel storage capacity may require a longer time frame.

Furthermore, considering both risks and opportunities associated with new investment in transportation and fuel delivery infrastructure may exceed a 10-year outlook. Continual maintenance and improvement of this infrastructure is necessary to secure Arizona's place in a globally competitive economy and enhance trade opportunities with partners both domestic and international.

To this end, new pipelines are in various stages of development. In particular, a new pipeline has been proposed that will connect Arizona's delivery of natural gas to Mexico, potentially impacting the fuel supply in both regions.

Permitting of pipelines and major transportation infrastructure is a significant factor for ensuring the state's energy future remains competitive. While the current regulatory process in the state is relatively smooth when compared to federal regulations, additional coordination with federal entities and other jurisdictions could further streamline the process.

TRANSMISSION

Current Status

Photo courtesy of National Renewable Energy Laboratory

A complex network of transmission lines supports Arizona's electric power system by transporting power from generation sources to the places where it is consumed.

Transmission of electrical energy in Arizona is conducted via high-voltage transmission lines, operating at a design voltage of 115 Kilovolts (KV) or higher. Lines carrying energy at voltages below 115KV are called "distribution lines" and are subject to different regulatory oversight.

Arizona presently has a robust transmission system that links electrical distribution points to sources of electricity, both within and outside the state. Some of the lines accommodate energy transmission from Arizona generators to users in other states, while others may perform a pass-through function to send energy generated from one state to a user in Arizona or to another state. Arizona's transmission system is an integral portion of a much larger system called the Western Grid. This complex grid ferries electricity around all the western states, as well as potentially to parts of Canada and Mexico. Similar grids exist in other portions of the U.S.

Transmission owners take great care to ensure that the system is operated and maintained properly to avoid brownouts or blackouts. Moreover, utilities and independent developers continuously assess the need for additions or improvements to the existing system. An evaluation process helps identify new transmission projects having several benefits. For example, new transmission may be necessary to ensure the grid operates reliably as power demand grows. New transmission may also be needed for new generation sources to deliver power to the grid. Furthermore, linking two neighboring systems can provide economic benefits by enhancing the ability to exchange energy resources.

Because the transmission system is highly interconnected, power delivery via transmission is recognized as a form of interstate commerce and is thus regulated by the Federal Energy Regulatory Commission (FERC).

In Arizona, transmission owners must plan their systems according to rules established by the FERC. Several entities have emerged over the years that help facilitate this planning process among Arizona utilities, including:

- WestConnect:[61] a regional planning entity composed of transmission owners in Arizona, New Mexico, Nevada, Colorado, and several other western states.
- The Southwest Area Transmission (SWAT) Subregional Planning Group:[62] a subregional group within WestConnect covering Arizona and New Mexico.
- Transmission Expansion Planning Policy Committee (TEPPC),[63] a committee of the Western Electricity Coordinating Council (WECC) that conducts planning across the entire Western Interconnection.

Transmission planning continues to evolve as new regulations and new practices emerge. Currently, utilities are focused on steps necessary to comply with a major new regulatory requirement known as FERC Order 1000. WestConnect has emerged as the regional planning entity for Arizona utilities under FERC's jurisdiction and will be responsible for conducting a region wide transmission-planning process.

While FERC has oversight over much of the transmission-planning processes that occur in Arizona, there are several key aspects of transmission planning that are not under FERC's jurisdiction. One is the siting of proposed new transmission lines, which is the responsibility of the Arizona Corporation Commission (ACC). Additionally, FERC does not have jurisdiction over many aspects of transmission planning by state-created entities or municipalities (e.g., Salt River Project). And finally, Arizona supplements the other planning processes with its own statewide planning effort known as the Arizona Biennial Transmission Assessment.

Entities proposing to construct a new transmission line or power plant must submit an application to the Arizona Transmission Line and Power Plant Siting Committee for review. After review, the committee may either issue or deny a Certificate of Environmental Compatibility. Issuance of the certificate would allow construction of the line, but only after the ACC reviews the action of the committee. The ACC may approve it, deny it or approve it with added stipulations. Evaluations of submissions for approval of a new transmission line concentrate on two items, as specified by Arizona law:

- Environmental compatibility
- Need

Applications for new lines feature multiple players, including the applicant, committee members, expert consultants, and interveners. The committee makes every attempt to make a fair and just analysis. Arizona's process is more efficient than those in many other states.

The ACC biennially reviews 10-year plans filed by parties intending to construct transmission facilities at 115 kV or above and issues a written decision regarding the adequacy of the existing and planned transmission facilities to reliably meet the present and future needs of the state.

As part of this review, the ACC produces a comprehensive report with detailed information on the status of Arizona's transmission system.

Challenges

Arizona faces two primary transmission challenges:

- Coordinating with separate governmental jurisdictions, some with differing objectives.
- Developing renewable energy because some of the best locations for these resources are places without transmission connections.

Arizona and its neighbors will continue to have demand for renewable power sources and developing renewable resources requires both an energy customer and a means of moving the energy to the customer.

Siting often becomes challenging due to the need to coordinate among local, state, and federal jurisdictions. A significant portion of Arizona land is controlled by federal agencies that frequently have different policy objectives from local or state agencies. In particular, projects that involve federal lands must undergo a lengthy and costly National Policy Review Act (NEPA) review process. Furthermore, transmission lines that cross state boundaries can make matters even more complex.

As Arizona strives to become the "solar capital of the world," transmission development is likely to be a critical enabler. As mentioned, some of the most productive locations for renewable energy, such as solar exist in remote regions and will require new transmission lines to deliver the power generated. Furthermore, solar is a "variable energy resource," meaning its output changes as the sun rises and sets or clouds pass overhead. As more solar is added to the grid, managing its variability will require new ways of planning and operating the transmission system.

Moving towards a transmission system that is more automated and regionally connected could help the system respond quickly to changes in power generated by solar. Linking together more areas with solar via transmission will also decrease the chances of a cloud in any one area interfering with power generation. Furthermore, with a robust transmission system, utilities

can reduce the amount of backup reserves needed for solar by sharing them across the system. All of these practices could help lower the cost of adding solar to the grid.

In addition to integration, finding another market for solar is also important. Arizona has traditionally exported about 25 percent of its conventional generation to California, bringing economic benefits to both states. However, the continuation of this export pattern and its economic benefits may require Arizona to invest in renewable resources, such as solar, because California has implemented policies that restrict the imports of fossil fuels. Further, California utilities' interest in Arizona solar may be limited by a lack of available transmission between the two states.

In the 7th Biennial Transmission Assessment (BTA) Arizona utilities:

- Identified several Renewable Transmission Projects (RTPs) within the state that are considered priorities for facilitating renewable energy development.
- Included a study of these projects' ability to increase exports of renewable energy to California.
- Concluded that certain transmission projects could help increase exports to California, but would need to be coordinated with California's planning process. [64]

Due to the current lack of demand for additional utility-scale solar within Arizona, expanding transmission capability between Arizona and California may be essential to expand the solar industry and the economic benefits it would bring.

10-Year Outlook

For the future, it is important to keep up with the needs of a growing economy in Arizona. New transmission projects will be necessary to serve the projected population growth and the accompanying new industries needed to create jobs.

Arizona could increase export capability by supporting and enhancing connectivity with Western energy markets. Proposed projects such as APS's Delaney-Colorado River and the North Gila-Imperial Valley and those under construction such as the Hassayampa-North Gila II, help enhance Arizona's ability to export energy to neighboring markets. Arizona could also work with the federal government on ways to streamline environmental permitting practices.

It will be important for Arizona policymakers to stay apprised of important developments that are already underway in the Western transmission grid.

Since the grid is interconnected, changes that may impact Arizona include:

- Energy Imbalance Market (EIM): CAISO and PacifiCorp recently entered into an agreement to develop a regional real-time market service, referred to as the EIM. An EIM aggregates the load and variability of electricity generation over multiple balancing authority areas and

utility territories. One of the intentions of an EIM is to improve the participating utilities' ability to manage intermittent renewable resources. An EIM may be a beneficial tool, but it is just one option among many to help efficiently and cost-effectively integrate renewable electricity generation. EIMs are still being studied to fully understand the costs associated with their implementation, which could potentially be significant to utility customers.

- California Transmission Planning: Today and in the future, California is expected to play a fundamental role in the Western transmission grid since it is the largest source of electricity demand.
- FERC Order 1000 Transmission Planning: Under this order, states can be compelled to coordinate on transmission planning and meet cost obligations for new electricity transmission capacity.

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5. ENERGY EDUCATION, WORKFORCE & ECONOMIC DEVELOPMENT

Arizona is positioned to be a leader in the energy sector due to its fostering of energy education, research & development, training, and innovative entrepreneurial enterprises through research collaborations and programs at the universities, community colleges and joint technical education centers. The future success of Arizona's energy industry depends on the incubation of this research, development of the state's energy workforce, and continued support of the business community.

The state is increasingly developing innovative new programs to build the next generation of energy leaders. This new generation of energy leadership is being primed to engage in a pivotal time of business growth. A pro-business regulatory culture with an improving economy has already proven to be a winning combination. Named the 2013 #1 State for Future Job Growth by *Forbes*[65], Arizona looks toward an economic future as bright as the state's summers.

ENERGY EDUCATION AND WORKFORCE DEVELOPMENT

Current Status

Arizona's energy-related education and workforce development efforts start with building a strong educational foundation for children, world class universities, training programs and significant options for school choice. The Governor's Office of Education Innovation through partnerships with the private sector, is working to coordinate workforce requirements with the state's education system by targeting the needs of employers in different Arizona industries in order to effectively align training and educational programs.

Through strategic partnerships, such as with the Science Foundation Arizona, state leaders are targeting Science Technology Engineering and Mathematics (STEM) education and have established the Arizona STEM network.[66] But in order for Arizona to have a well-rounded and globally competitive workforce, it must also address workforce shortages in the skilled trades by marketing careers in technical trades to students through various programs.

Programs in place include Joint Technical Education Districts (JTEDs). Arizona's JTEDs encompass 13 separate schools statewide that have programs specifically designed for workforce development, certification and training. For example, the East Valley Institute of Technology offers opportunities for Arizona students to integrate technical training into their academic programs.[67] Other programs include utility partnerships with colleges, universities, and K-12 schools, as well as local partnerships between K-12 schools and community colleges that focus on local industries. Arizona is also working to establish additional programs.

Once younger energy workers join the industry, it is important for their careers to be supported with the training they will need to take over the roles of retiring industry workers. A number of programs have been developed across Arizona to provide this training in energy-related jobs, including training programs for trade associations, Navy-based training for nuclear operators, apprenticeship programs, and corporate training programs.

Grant funds STEM Program for American Indian, Hispanic Youth

Photo courtesy of Southwest Institute for Research on Women

"With a National Science Foundation grant at nearly $1.2 million, the University of Arizona Southwest Institute for Research on Women ["SIROW"] and its partners have established i-STEM. Part-mentoring, part-academic training including informal science activities, the hybrid program will target 60 students in grades third through eighth focusing on the ever-important science, technology, engineering and mathematics, or STEM, fields…SIROW is collaborating with the University of Arizona's (UA) colleges of engineering and education, the Women in Science and Engineering (WISE) program, StrengthBuilding Partners, the Pascua Yaqui Tribe, and also Lawrence Intermediate and Hohokam Middle schools…near the Pascua Yaqui Reservation."

Governor Brewer recognizes that addressing the state's workforce development is paramount to retaining existing businesses, growing Arizona-based businesses and attracting new industry. In January 2013, the Governor signed Executive Order 2013-01, which established the Arizona Workforce Council to address the state's need to integrate workforce development efforts with the state's education system, and equip workers with the skills they need to enter the workforce.[68] She also created the Governor's Office of Workforce Development (GOWD), which focuses on improving job training and marketability of Arizona's workforce, thereby helping drive future economic growth for the state. GOWD works closely with the Arizona Workforce Council, the Arizona Commerce Authority, the Arizona Department of Economic Security, the Arizona Department of Education, Arizona Ready and Arizona's other workforce development stakeholders.

Challenges

As Arizona's energy demand grows, so does job growth in the energy sector. Local utilities are often a key source of energy jobs and long-term employment; however, according to a 2011 national survey by the Center for Energy Workforce Development[69], the average age of the workforce has increased to 46 years and the number of employees with more than 30 years of service has increased by 5.2 percent since 2006. The aging of Arizona's existing energy workforce is a challenge that the state will have to address in the coming years. To fill the gap left by older workers exiting the industry, a younger generation of energy workers must step into their roles and the new roles created by expanding energy business opportunities and technology development.

The challenge lies in making careers in energy-related technical industries more appealing to K-12 and college students. As Arizona seeks to attract students to the energy industry, effective communication with students and school counselors will be essential. Students and counselors must understand the advantages of energy-related careers: mobility, sophistication, earning potential, and varied opportunities.

Estrella Mountain Community College Consortium Awarded a Department of Labor Grant to Address Arizona's Energy Workforce Needs

Photo Courtesy of Estrella Mountain Community College

In 2012, "[a] consortium led by Estrella Mountain Community College (EMCC) – one of the ten Maricopa Community Colleges" was awarded "a $13.5 million grant from the U.S. Department of Labor to bolster Arizona's energy workforce needs…The initiative advances sustainable solutions to meet critical industry demands while improving the content and delivery of Sun Corridor education and training programs. The initiative will also propel current and future employees to move into an energy job or other occupation requiring similar skill sets, such as technicians, line workers, plan operators, skilled craftsmen, and engineers."

10-Year Outlook

In order for Arizona to continue strengthening its energy workforce, public and private organizations must continue to proactively target educational programs to meet energy industry needs. In the future, the state must continue these efforts to develop innovative education opportunities that address changing industry needs and prepare Arizona's students for leadership in energy careers.

Addressing the need to develop a workforce to replace aging energy employees requires an effective marketing campaign publicizing opportunities available to students, as well as educating counselors and teachers about the existence of current training and educational programs. In order to measure outcomes of training and educational programs, the public and private sector must analyze the effectiveness of such programs and make certain that educational and training opportunities are aligned with the workforce needs of area businesses.

ENERGY ECONOMIC DEVELOPMENT

Current Status

Because of pro-business policies, strategic partnerships, population growth and the Governor's leadership, the state of energy-related business in Arizona shows great opportunity for economic expansion and job growth.

In order to identify, attract and retain energy-related companies, economic development organizations and initiatives have been created at both state and local levels. Serving as the backbone of business retention and attraction efforts are public-private partnerships such as the Arizona Commerce Authority (ACA) and regional organizations such as the Greater Phoenix Economic Council (GPEC), Tucson Regional Economic Opportunities, Inc. (TREO), the Economic Collaborative of Northern Arizona (ECoNA), and the Greater Yuma Economic Development Corporation (Greater Yuma EDC).

These organizations, the Governor's business tax incentives and reforms, and business development initiatives (such as the Arizona Competes Fund), multiple apprentice programs, the Arizona Job Training Program, and the Quality Jobs Tax Credit have helped to diversify Arizona's economy and provided incentives relative to notable business expansion projects including:

- GoDaddy's expansion with 300 new jobs.
- Waste Management facility expansion bringing 776 new jobs.
- Intel Corporation's research and development facility that will add a projected 648 new jobs by 2014.

The Governor also recognizes that Arizona's location and climate create opportunities in new energy technologies. Her enactment of a solar tax incentive program in 2010 has translated to over $1.2 billion of investment in the Arizona economy.

Arizona's climate and strategic location next to major domestic and international energy markets affords the state's energy-related businesses access to growth opportunities as those markets evolve in the coming years. Businesses in Arizona also see a high regional demand for products, creating opportunities for industries that support energy-related ventures to drive long-term economic development in the state.

Challenges

To attract new businesses, Arizona must keep up with other states in the quest to develop optimal work and home environments for energy companies and their employees. A key challenge for the state as it moves forward is effectively communicating Arizona's business development success stories, strong education programs, talented young workforce, and pro-business regulatory culture.

Additionally, the state's economic developers and public and private sector stakeholders must work together to provide as much regulatory certainty as possible to ensure they address expansion and attraction of risk-averse businesses. Establishing collaborations between government and industry on policies and efforts that support businesses in the state will be key to growing the energy industry in the state.

In supporting both energy- and non-energy-related businesses in Arizona, energy infrastructure is needed to move electrons and provide access to reliable, low-cost power across the state. As companies relocate or expand their businesses in Arizona, different areas of the state have varying levels of infrastructure development to support new business. Challenges include centralizing statewide business-development efforts and attracting foreign businesses to urban as well as rural areas.

While Arizona has a strong foundation of business development policies, the challenges for policymakers will be to strengthen policies that promote energy business development and to address the need to provide regulatory and rate consistency for businesses.

In order to meet specialized economic conditions, utilities may need more flexibility in pricing, such as pricing structures which allow for the attraction of heavy energy users who would serve as regional economic development and employment centers, and "on-peak" pricing, particularly when there is capacity to meet energy demand. Most efforts related to this would require actions by the Arizona Corporation Commission.

10-Year Outlook

Arizona is anticipated to experience a 15 to 20 percent increase in peak energy demand over the next decade. Export opportunities are likely to increase for a variety of reasons, including demand growth in California, plant retirement, and additional renewable energy integration. A likely result of these export opportunities is an increase in energy-related construction and operational employment in Arizona.

In order to plan for future energy-related development opportunities, the state should look to national and global trends in policy development. In 2013, the GOEP was awarded a competitive grant to participate in a National Governor's Association Policy Academy on advanced energy and economic development resulting in Governor Brewer announcing the Arizona Collaboratory for Advanced Energy Solutions at the 2014 Governor's Economic Development conference. This project is ongoing with stakeholders from the Governor's Office, Senate, House of Representatives, Arizona Corporation Commission, Arizona Commerce Authority, and the state's universities. Policy efforts and strategy should focus on building a more stable economy to broadly support clean energy business development within the state, and provide stable regulations for businesses.

TAX REVENUE DATA

According to the Arizona Department of Revenue's 2012 Annual Report, net revenues to Arizona's General Fund have increased in recent years, although they have yet to meet 2008 levels.

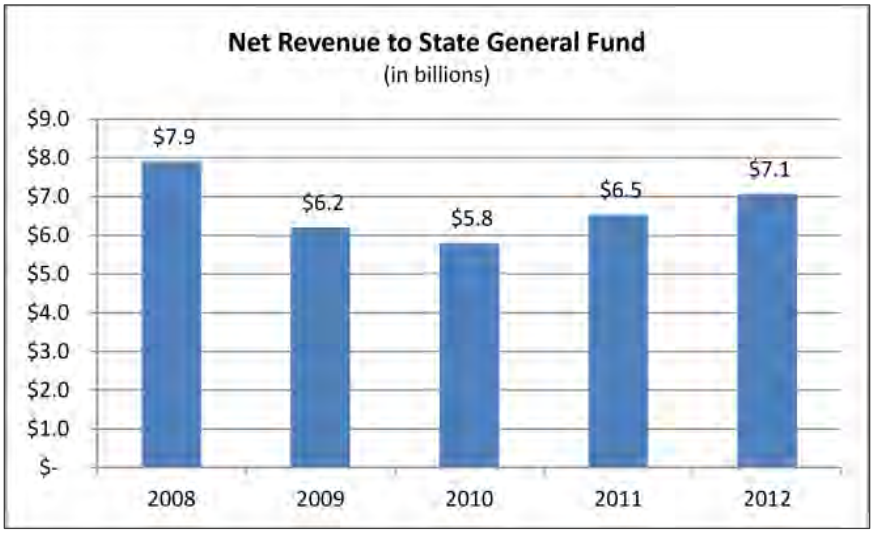

Figure 18

EMPLOYMENT DATA

The Arizona Department of Administration (ADOA), Office of Employment and Population Statistics, Special Unemployment Report, indicates that unemployment has decreased in recent years.

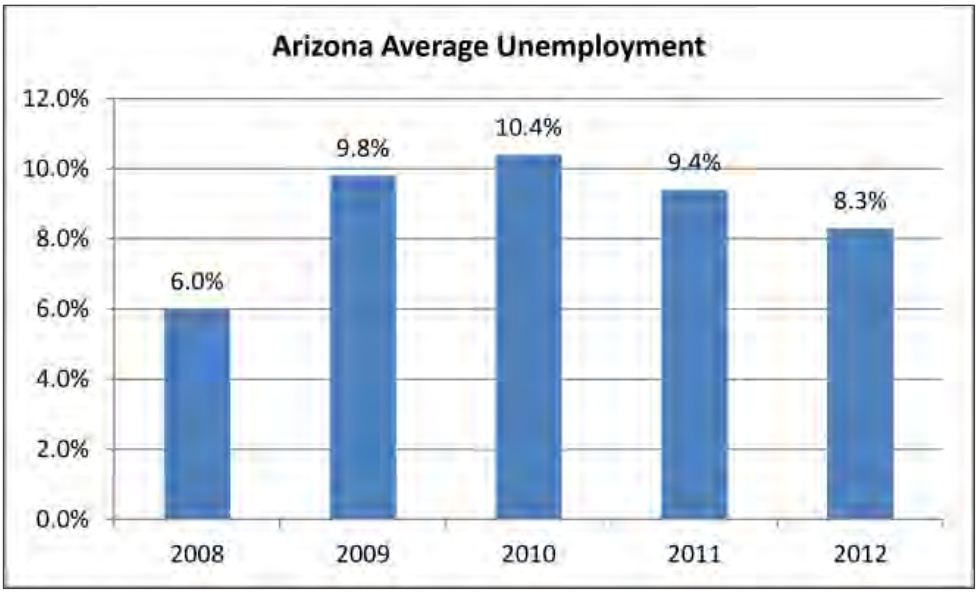

Figure 19

However, forecasts relative to nonfarm employment show a positive future trend, according to ADOA's 2012-2013 employment forecasts.

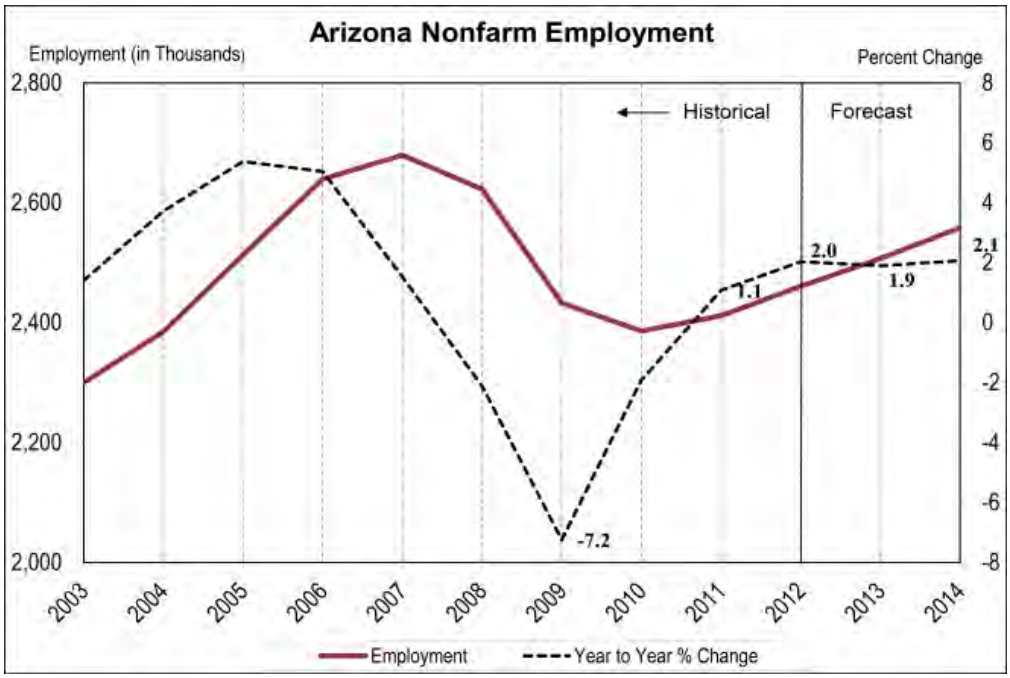

Figure 20

The makeup of Arizona's nonfarm employment is well-diversified with the majority of nonfarm employment occurring in the Trade, Transportation and Utilities sector.

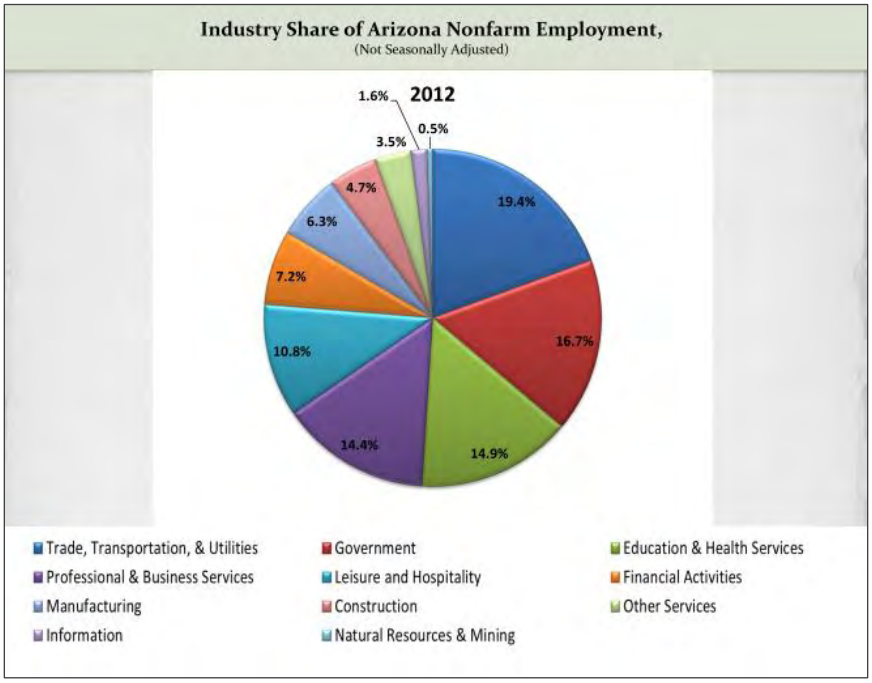

Figure 21

Forecasting by ADOA indicates that growth in the trade, transportation and utilities sector will outpace overall growth in nonfarm employment through 2014.

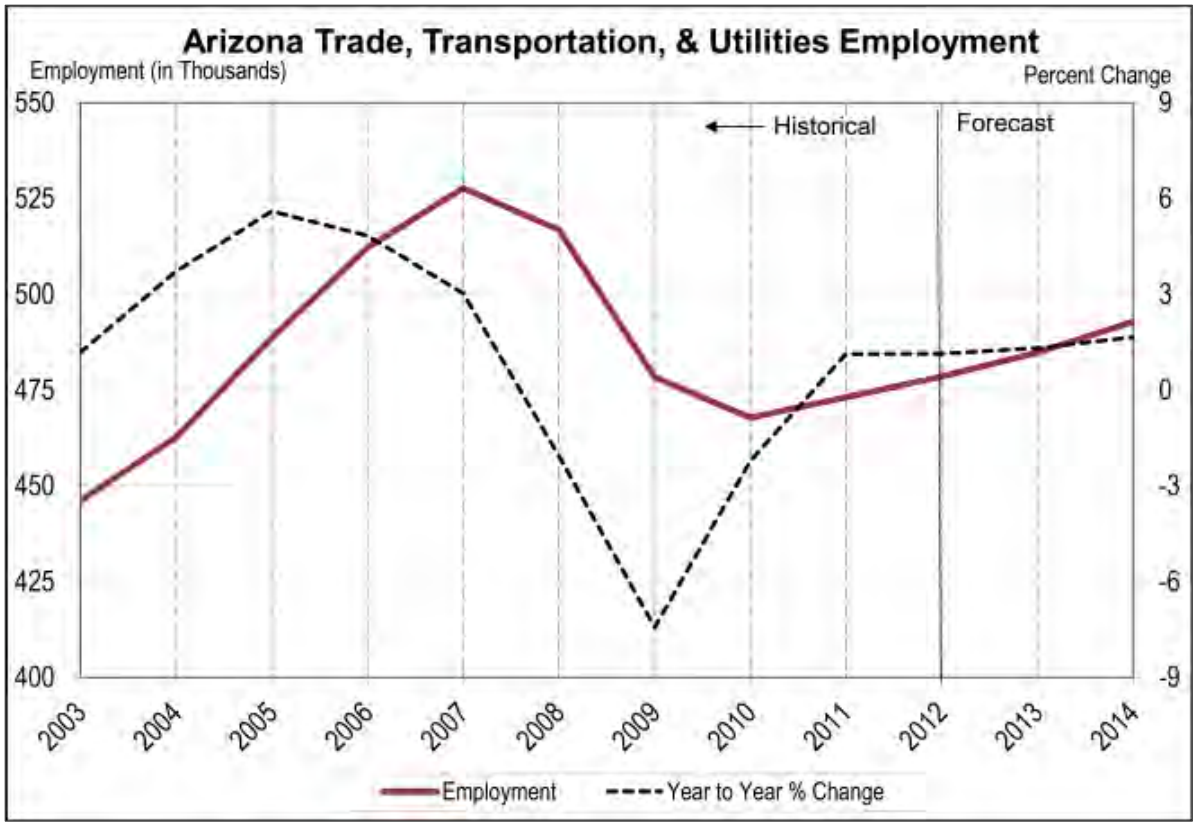

Figure 22

This data indicates that the Trade, Transportation and Utility sector relating to energy is the largest and will continue to be the largest nonfarm employment sector in the near future.

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6. THE UNIVERSITY ENTERPRISE & EMERGING TECHNOLOGIES

Governed by the Arizona Board of Regents (ABOR), Arizona's universities – the University of Arizona (UA) in Tucson, Arizona State University (ASU) in Tempe, and Northern Arizona University (NAU) in Flagstaff – are a $4 billion enterprise and have a total enrollment of more than 140,000 students. These universities share a common commitment to providing high-quality educational programs, sustaining academic excellence, and turning out a highly qualified workforce.

In 2010, ABOR's strategic realignment of the university system focused in part on enhancing energy-related programs. As a result, each university has developed semi-autonomous platforms designed to meet Arizona's overall energy-related educational and economic development goals. Individual university programs include research and development initiatives that:

- Help commercialize emerging technologies.
- Coordinate with companies incubated through the university system.
- Explore new energy technologies that have the ability to change the way energy is consumed, generated and produced.

UNIVERSITY OF ARIZONA

Founded in 1885, as one of America's land-grant universities, the University of Arizona (UA), operates the state's only public colleges of medicine, pharmacy, public health, and agriculture.

In 2013, UA President Ann Weaver Hart led development of the "Never Settle" plan for a modernized understanding of the land-grant university. Never Settle recognizes that partner relationships with communities and industries are central to UA's mission to have real-world, local and global impacts.

UA has made a commitment to energy-related research and development, specifically solar, through the Arizona Research Institute for Solar Energy (AzRISE). AzRISE research encompasses photovoltaic testing, efficiency and economically feasible storage options, understanding policy and economic impacts, and building an integrated smart grid.

Other significant energy-related research being conducted at UA includes:

- Storage Management Research and Testing (SMRT), a partnership between the university, Solon Corporation and Tucson Electric Power (TEP) to study the integration of storage technologies including chemical batteries, electrical super capacitors and thermal energy storage on the electrical grid.
- The Bright Tucson project, a partnership between AzRISE and TEP, utilizes multiple storage-and-demand response technologies to enhance resource optimization software.
- The Department of Civil Engineering and Engineering Mechanics conducts water-energy nexus research and is currently building computer models that will help water managers assess increasing water demand.

In 2011, UA rolled out Tech Launch Arizona (TLA), a new initiative designed to leverage UA intellectual property in order to contribute to the economic development of southern Arizona. As a result in 2012, TLA helped establish five new companies using UA technology. Three of the five companies are in Arizona, including one energy company, REhnu, which brought solar-concentrating technology developed at UA into production. It holds an exclusive license to commercialize this patent-pending technology.

ARIZONA STATE UNIVERSITY

Founded in 1885, ASU advanced in 1958 from a territorial teachers' academy to one of the nation's largest universities with a high-performing, comprehensive research component.

Under the leadership of President Michael Crow, ASU has become an internationally recognized research institution with a strong focus on "use-inspired" basic research and defense-relevant research.

Arizona State University Partners with Sandia National Laboratories to Develop Research and Workforce Development Opportunities in Renewable Energy

In 2013, Arizona State University entered into a partnership with Sandia National Laboratories to "advance research, education, workforce development programs and policy endeavors…[which] enables the two institutions to more easily work together to secure new research funding, establish multidisciplinary partnerships, and advance innovation and entrepreneurship in science, technology, engineering and mathematical disciplines in turn building a workforce pipeline."

ASU supports energy innovations at all stages, from basic research to technology transfers and startup companies. Its LightWorks Initiative combines all of ASU's light-inspired research, including:

- ASU Solarization Initiative, which at 66 systems is the largest solar portfolio of any university in the United States.
- Algae testing.
- Power systems engineering research.
- Energy-related policy research.

Project highlights include:

- A DOE award of $15 million for the Algae Testbed Public-Private Partnership (ATP3), supplemented by $2 million pledged by Governor Brewer. ATP3 functions as a testing facility for the algal research community, supports the operation of existing outdoor algae cultivation systems, and allows researchers access to real-world conditions for algal biomass production.
- Quantum Energy and Sustainable Solar Technologies Center, one of the leading testing and certification centers for solar energy.
- Power Systems Engineering Research Center's (PSERC) workforce development program that creatively addresses the challenges facing the electric power industry.

Established in 2003, the Arizona Technology Enterprise (AzTE) is the exclusive management and technology transfer organization for ASU. Since 2009, based on annual licensing surveys by the Association of University Technology Managers (AUTM), ASU, through this program, has been one of the nation's top-performing universities in terms of Intellectual Property (IP) inputs (inventions disclosed to AzTE by ASU researchers) and outputs (licensing deals, option agreements, and start-ups based on university IP) relative to the size of the university's research enterprise.

AzTE's venture development activities have led to the formation of 55 companies.

Energy companies established through the technology transfer include:

- Heliae Development, LLC, is an algae biofuels and nutraceutical development company launched in 2008 to develop a technically viable, scalable, end-to-end process to produce algae-based solutions for the food, fertilizer, pharmaceutical, fuel, green chemical and cosmetic industries.
- Fluidic Energy, founded in 2007, makes metal-air batteries that have the potential to store three to four times that of lithium ion batteries.[70]

NORTHERN ARIZONA UNIVERSITY

Founded in 1889, the Northern Arizona Normal School had a total enrollment of 23 students and one professor.

Today under the leadership of President John D. Haeger, NAU has experienced rapid enrollment growth reaching a record student population of 25,000 among its three campuses – Flagstaff, Prescott, and Yuma. The Flagstaff campus has the largest enrollment with 17,000 students. NAU has more recently renovated and constructed 25 new buildings, including four certified Leadership in Energy and Environment Design (LEED) buildings; the *Princeton Review* cited it as a "green building superstar."

Northern Arizona University Institute for Sustainable Energy Solutions

The Institute for Sustainable Energy Solutions (ISES) at NAU is designed both to train future energy leaders and contribute to energy policy-making conversations. "ISES is a regional and national leader in wind energy research, with projects that reach internationally… ISES provides wind maps and data for Arizona, has wind resource assessment capabilities, and performs research projects related to grid integration of wind power, wind-resource modeling, and wind-energy economics and policy."

Demonstrating NAU's commitment to sustainability and energy-related research and new technologies, it established the Institute for Sustainable Energy Solutions (ISES) with key focus areas in sustainable renewable energy: wind, solar, synthetic fuels, energy utilization, and geothermal.

ISES research and testing capabilities include:

- The Arizona Wind Working Group (AzWWG): funded through the U.S. Department of Energy Wind Powering America Program; NAU is the lead organization and responsible for managing the group.
- The Arizona Synthetic Fuels Project: focuses on capturing and recycling carbon dioxide from the atmosphere while harnessing the power of renewable electricity in order to produce a carbon-neutral liquid fuel fully compatible with our existing gasoline infrastructure.

- Through the Energy Utilization study, ISES's Energy Efficiency and Smart Grid research programs have partnered with: the College of Business and College of Social and Behavioral Sciences to perform qualitative research on the human dimensions of energy conservation and utilization behaviors and conduct research related to energy efficiency on Native American lands.

As Arizona's leading university in wind energy, NAU has statewide partnerships that cultivate and develop energy-related employment and workforce development. According to the Carnegie Foundation, there are 4,634 institutions of higher education in the United States, 207 (5 percent) of which constitute the country's most active research universities. As a designated "High Research" university with expenditures ranging between $25 and $30 million, NAU falls within that 5 percent. NAU has also leveraged more than $529,000 in funding for alternative energy research and technical assistance for communities around the state.

NAU also partners with the Northern Arizona Center for Entrepreneurship and Technology (NACET) incubator, which has a wide variety of non-retail, service, manufacturing, high technology, science and renewable energy firms including:

- Nest Energy Systems which utilizes advanced solar and wind technologies to replace diesel generators for the military. The company's systems have been deployed domestically and at the Iraq-Kuwait border, in Afghanistan, and in Africa.
- Sedona Solar Technology, founded in 2007 as Sedona Energy Labs, which develops and manufactures practical, cost-effective tracking technology for the solar energy sector.

THE UNIVERSITY ENTERPRISE

Current Status

As the university system moves forward to adapt to changes in the social, cultural, economic and technological dynamics of Arizona, its role since the state's founding remains unchanged: to provide broad access to an innovative, world-class university education for all segments of Arizona's society.

Over the past few decades, the research enterprise has expanded to nearly $2 billion per year, second only to California in the western U.S. These university research expenditures flow down to private sector activities, having a significant effect on both the level of industrial research and development and the transfer of technology to the public. University research results in significant accomplishments that can be measured by inventions, patents, and start-up companies, all of which fuel the private sector and translate into high-paying, highly skilled jobs.

According to the 2012 ABOR Annual Research Report[71], the university research multiplier could be as high as 7 or 8. In other words, a $100 million research grant could have a total impact in Arizona of about $750 million.

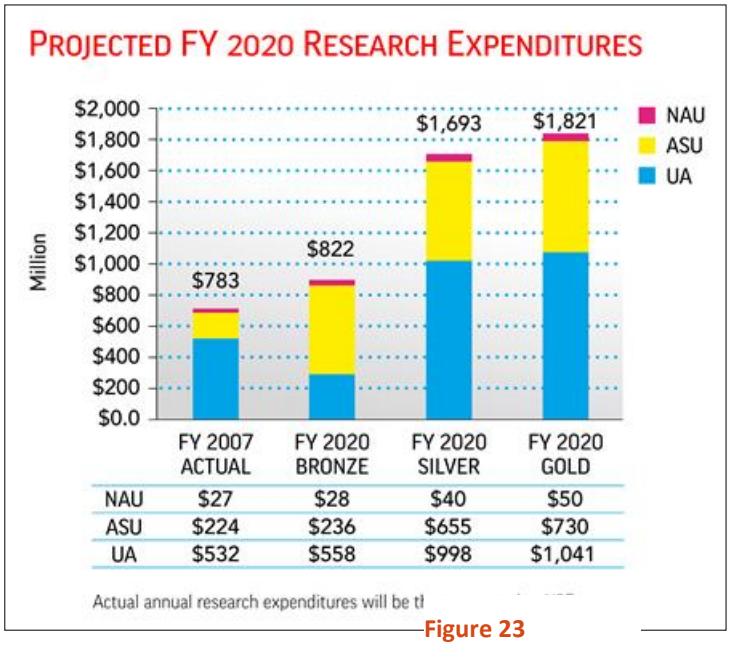


Figure 23

Also according to the same ABOR report, the Technology and Research Initiative Fund (TRIF) is a small portion of the entire university research enterprise, but this fund significantly illustrates the return on research investment.

In 2008, UA's investments from TRIF yielded about $5.70 for every $1.00 invested. In the same year, ASU generated almost $4 for every dollar invested in grant and contract expenditures. NAU is generating $3.50 of competitive funding for every TRIF dollar invested.

Challenges

Strong pipelines of students are key to the University Enterprise, specifically to the energy research and development sector. Because the energy industry throughout the U. S. is staffed by an aging workforce, educators and industry leaders are striving to attract K-12 and college students to energy-related careers. More robust communication is needed to inform parents, teachers, counselors and students of the energy-related career benefits: mobility, sophistication, earning potential, and variety of opportunities.

Another challenge is increasing public financial support for energy research and technology development at all stages. In particular, promising technologies often suffer from lack of funding during two stages: the transition from basic, applied research and prototype, then the transition to commercial scale. Energy technologies often require large amounts of up-front capital with a long-term horizon until they become viable commercial products. Increased public-private partnerships and greater public policy support for innovative energy research and development at our state universities will keep Arizona at the forefront of energy innovation.

10-Year Outlook

During the next 10 years, the University Enterprise (ASU, NAU and UA) will pursue research into coal gasification and carbon-capture and sequestration technology development, algae research for alternative transportation fuels, and energy-storage technologies.
The Arizona Board of Regents, in partnership with university presidents, has established research funding goals to be accomplished by 2020.

The goals are comprised of Bronze, Silver and Gold. Although there is a tiered-goal structure, each goal is a measured improvement over the current state of research dollars generated by each university.

Arizona's public universities conduct research that is responsive to community needs and push their discoveries and inventions into the community for practical and beneficial use. Formal technology transfer through the licensing of intellectual property is a key facet of a broader portfolio of knowledge transfer. Licensing provides a mechanism for entrepreneurial commercialization of products and generates revenues that can be reinvested in the universities' research enterprises.

EMERGING TECHNOLOGIES

MICROGRIDS

Current Status

Modern electrical systems consist of two major components, generating stations and a vast network of wires called a "grid," whose function is to ferry electricity from its point of generation to its end use. Energy moves through the grid at very high voltages, typically in the 230-500 KV (thousand-volt) range. The large grids feed into a network of lower-voltage wires called distribution lines at voltages below about 100KV. This transition takes place at a facility called a substation, which uses transformers to change the voltage. Finally, at the neighborhood level, additional small transformers drop the voltage further, typically to 120, 240 or 480 volts.

During the beginning of electrification the first grid, deployed in the New York City area, was very small. At first, customers were few and far between, and the early grids were typically neighborhood-based and not interconnected with one another. Very quickly, the convenience of 24-7 electricity for homes and businesses became apparent, and the revolution was underway.

The U.S. is divided into four large grids, with Arizona situated in the Western grid. Over the years, trillions of dollars have been invested in these facilities.

Today, instead of a series of those smaller, independent grids, developed countries like the U.S. have very large, interconnected systems, with many entities participating in the ownership and operation of the system. While this network produces great economies of scale, it also occasionally results in problems such as outages. In such cases, grid operators have the ability to quickly isolate portions of the grid from the whole, allowing for repairs.

Currently, innovations in the energy field represent a throwback to the first small, neighborhood grids of the past. Small "microgrids" operating at relatively low voltage move

electricity throughout a very small area. This electricity is not produced by central station power plants like the Palo Verde Nuclear Generating Station, but by smaller sources of generation such as solar or wind arrays, or even a gas-fired combustion engine. For example, the military is developing microgrids to support its distributed generation or "off-grid" needs.

An obvious use for such an arrangement is a small group of homes, or a group of businesses like lumber yards or mines which are located far from the main grid. Alternatively, such microgrids are finding applications in more urbanized settings, with certain users who are motivated by the opportunity to use "green" sources of electricity like solar, wind or geothermal; some states have created a legal framework to encourage this movement.

Some of the microgrid systems are stand-alone, while others will have the ability to safely interconnect with the large grid.

Challenges

While some states are moving forward with the microgrid effort, there is relatively little research to demonstrate how economical and plausible it will be in the shorter-term.

Industry players in the large electrical system are also voicing two major concerns about this movement: first, it could displace a significant portion of their customer base; and second, interconnected microgrids pose issues related to reliability, dispatch, and other features of the overall system. Proponents of microgrids say the opposite is the case, with the smaller, geographically distributed generation being an asset, representing backup in case of emergencies or other disruptions which often occur randomly.

10-Year Outlook

All signs point to the microgrid movement continuing. Just like other new technologies, or in this case a movement to towards smaller centralized grids, there will be advocates and skeptics. The next decade will be sure to uncover the advantages and problems associated with microgrids.

BIOFUELS

Current Status

Biofuels are fuels derived from biomass or waste feedstock, including ethanol, biodiesel and algae. Over the past decade, global production of biofuels liquid and gaseous fuels has been growing steadily from 4.2 billion gallons annually in 2000 to more than 26 billion gallons in 2011. Today, biofuels provide around 3 percent of total road transport fuel globally and considerably higher shares are achieved in certain countries.

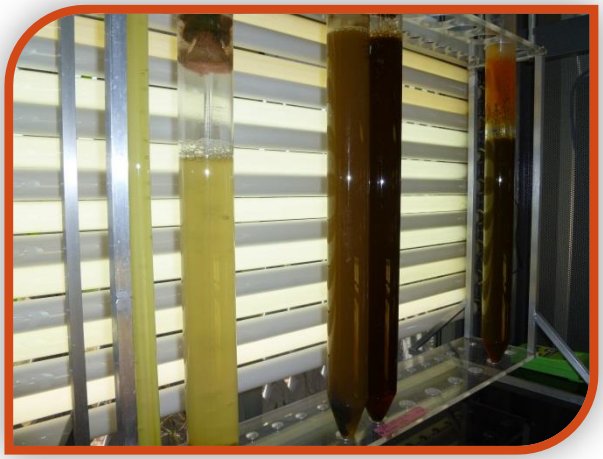
Brazil, for instance, met about 23 percent of its road transport fuel demand in 2009 with biofuels; according to the International Energy Agency (IEA). Algae is a biofuel currently researched in Arizona that shows potential for greater development and deployment.

Challenges

Challenges regarding biofuels include the relative cost of inputs vs. outputs as well as the fact that current production processes do not always meet expected net life-cycle greenhouse gas (GHG) emission and cost-performance targets. Also certain conventional biofuels have been criticized for causing deforestation and adding to pressure on agricultural land needed for food production.

10-Year Outlook

The emphasis in the next decade will be supporting advanced biofuels research, development and demonstration, and providing sound support mechanisms to ensure that the new technologies reach full market deployment. However, any economic incentives should be transitional, decrease over time and aim at encouraging the full competitiveness of alternative fuels.



Algae development at Arizona State University

ALGAE

Current Status

Interest in algae as a renewable fuel feedstock, as well as for renewable chemicals, therapeutics, nutritional supplements, cosmetics, feed, fiber, fertilizer, and food continues to grow steadily. Commercial-scale quantities of fuel from algae are starting to move to the consumer market.

The Algae Biomass Organization (ABO) hosted the recent Algae Biomass Summit 2013 held in Orlando, Florida. It was the world's largest event focused on algae technology. At the summit, industry leaders from Sapphire (California and New Mexico) and Algenol (Florida) announced that they will meet production capacities in excess of 1 million gallons in the next year. In addition, one of the pioneering algae companies, Solazyme (California) announced that it has delivered renewable fuel into commercial distribution through an alternative fuel retailer, which demonstrated through a small-scale market research study consumer preference for algae-based fuels. However, these accomplishments represent only the beginning of the potential impact the supply of renewable fuels derived from algae can have.

Arizona has a long history of research and development (R&D) in algae-based technologies for renewable energy and other valuable products. Decades of research at Arizona's universities recently culminated in the award of $15 million to lead the Algae Testbed Public Private Partnership (ATP3). ATP3, currently funded by the U.S. Department of Energy (DOE), is one of the largest grants for R&D on algae-based biofuel and related technologies. In addition, the UA was recently awarded an $8 million DOE grant to fine tune its proprietary, open-air algae farming system called ARID-HV (Algae Raceway Integrated Design – High Velocity).

These recent awards reinforce Arizona's recognized leadership role in algae-based R&D and build substantially on the significant local, private, state, and federal investments made in Arizona's research institutions.

Commercialization of algae-based products and the establishment of a high-tech algacultural energy industry have become reality with the recent completion of Heliae Development LLC's commercial production facility in Gilbert, with planned delivery of its first products in late 2013. Like many other algae companies, Heliae initially focused on producing fuel from algae but has diversified its product offerings, targeting significantly higher-margin product markets such as: algal oils for cosmetics; nutritional oils; and, through a recently announced partnership with Triton Health and Nutrition, algae-based therapeutics. This diversification allows for a company to prove out the scalability and economics of a technology platform while achieving necessary short- to midterm-revenue. As the technologies and operations mature, operational and capital cost reductions will allow the technology to eventually reach more commodity-driven markets (e.g., fuel).

Challenges

The ABO annually surveys its 5,000+ members, asking for opinions and projections on the industry's growth, barriers to advancement and policy priorities through 2020. More than 470 people participated from every segment of the algae industry. According to the survey's Executive Summary[72]:

- Ninety-one percent of respondents said it is likely that algae-based fuels will be cost-competitive by 2020, with nearly one in four (23 percent) of producers saying the price will be below $3 per gallon by 2020.
- Employers confidently predicted job growth in 2013; however, confidence in job growth through 2020 was less certain: some employers projected significant growth while others (up to 30 percent of ABO members) were unsure about their 2020 employment figures.
- Ninety percent of employers say better federal policy support would likely accelerate hiring.
- Producers identified the industry's most critical challenges to achieving cost-competitiveness were cost-efficient production, harvesting and extraction systems.
- Sixty-five percent of respondents' organizations said congressional engagement is high; they have either met with or plan to meet with legislators.

- Respondents identified the most important federal policies in building a robust algae industry as R&D, commercialization grants, and Tax Credits/Incentives. Additionally, the #1 response to implementing policies that would best help build a robust algae industry was: "Designation of algae as an agricultural crop by USDA or other agencies."

Although the current state of technology for algae-based products (including energy and other higher-value products) continues to advance towards and achieve commercialization, significant challenges and barriers remain, especially for large-scale energy production from algae. Barriers include per-gallon production cost and advanced production methods. Through continued investment in R&D at local, state, federal, and industry levels, these remaining technical and economic barriers are likely solvable. Arizona's algae R&D community is playing a significant leadership role in developing and proving those technical and economic solutions.

10-Year Outlook

Arizona continues its efforts to become a national leader in developing the potential economic benefits of algaculture. In 2012, Arizona passed new laws that will make algae production much more attractive, thus attracting jobs, investment and new research. Bipartisan legislation was signed into law by Governor Brewer allowing algaculture to be defined as agriculture on state trust lands. In addition, legislation was passed that will tax land used for algaculture in the same manner as agricultural land.

The state is well-positioned to capitalize on our recognized leadership position in algae-based technologies from fuel to feed, fertilizer to advanced therapeutics, cosmetics to nutritional supplements. Arizona has significant academic and industrial R&D, investment and commercialization. Continuing a pro-active focus on developing the economic, social and regulatory policies is favorable to a high tech algaculture industry. The state can advance this new industry bringing with it jobs and economic diversification essential to long-term prosperity.

ENERGY STORAGE

Current Status

Electric utility systems around the world today consist of two major hardware subsystems: generation and transmission. Trillions of dollars have been invested in the U.S. alone to build these facilities. But moving forward, what is desperately needed to create a balanced system, is energy storage – whether direct storage of electrical energy such as batteries, or indirect storage of energy in some other form, which is easily converted into electricity.

Storage capability will be critical as we move into innovations like the smart grid, expanded renewable energy generation and High-Voltage Direct Current (HVDC) transmission (which has fewer losses than Alternating Current transmission).

Energy storage will provide many benefits to the electrical system, including increased reliability, more flexibility, high renewable-generation content, and lower cost. Arizona is leading the way on utilizing storage in the Solana CSP Solar, which can store up to 6 hours of energy.

Challenges

While there have been different attempts to establish energy storage to balance the system, these attempts have not been scalable due to costs and broad distribution of research funding. Currently, federal monetary resources are insufficient for meaningful research to create scalable energy storage technologies.

10-Year Outlook

The U.S. should narrow the field of study to the most viable storage options, since there are not enough funds to pursue them all. The National Renewable Energy Laboratory (NREL) has excellent capabilities in this area and has studied storage in the past. Collaboration between colleges and universities in the Arizona University Enterprise could accomplish the same goal and current studies are analyzing the feasibility.

NUCLEAR RECYCLING

Current Status

La Hague plant in Normandy

While nuclear plant operators in the U.S. have developed safe and secure interim storage technology for spent fuel, it is still necessary for the federal government to resolve the political impasse on long-term storage, which was discussed under Nuclear in the Energy Resources section.

A French company, AREVA, has had success in reprocessing and recycling nuclear power generation fuel. Used fuels from reactors are sent to AREVA's La Hague plant in Normandy for reprocessing.

Challenges

All reprocessing options currently available or being developed still generates some waste that requires permanent disposal.

10-Year Outlook

This technology has the capacity to reprocess up to 1,700 metric tons per year of used fuel. The treatment extracts 99.9 percent of the plutonium and uranium for recycling, leaving the rest of the used fuel material as high-level wastes which are vitrified and stored for disposal. It does not seem likely that recycling efforts will be seriously considered until the federal government finds a solution for long-term storage of spent nuclear fuel.

FUEL-CELL TECHNOLOGY

Current Status

Fuel cells generate electricity through a chemical reaction between its cathodes, the positive (anode) and the negative (the cathode). A single fuel cell generates a tiny amount of direct current (DC) electricity. In order to increase generation, fuel-cell technology entails assembling many cells into a stack.

Challenges

Developing fuel-cell technology is complicated and, at this point, not cost-effective relative to other forms of energy. But fuel-cell technology can increase energy efficiency and benefit the environment.

Hydrogen fuel cells are the most popular type of fuel cell promoted in energy circles. Hydrogen is the basic fuel in, but fuel cells require that oxygen enters the cell at the cathode where it combines with electrons returning from the electrical circuit and hydrogen ions that have traveled through the electrolyte from the anode. The appeal of this type of fuel cell is that electricity is generated with very little pollution. The hydrogen and oxygen used in generating electricity ultimately combine to form an environmentally benign byproduct, namely water. Other types of fuel cells include: alkali, molten carbonate, phosphoric acid; proton exchange membrane; and solid oxide.

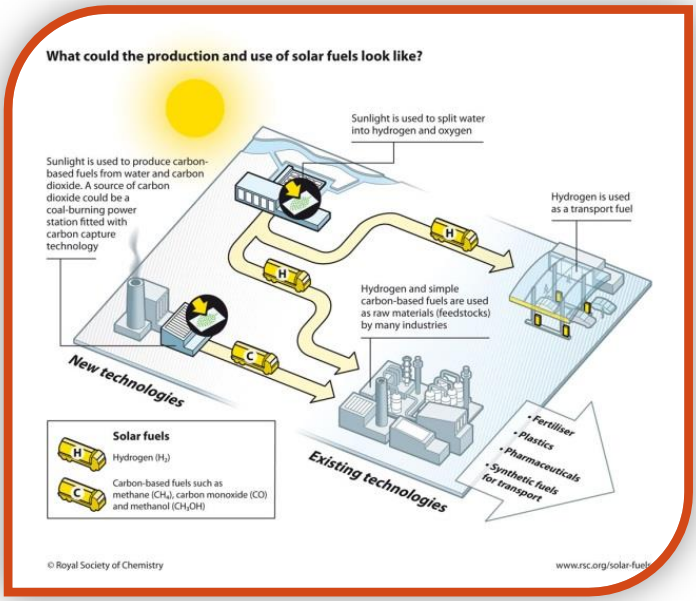
Since these fuel cells create electricity chemically, rather than by combustion, they are not subject to the thermodynamic laws that limit conventional power plants as demonstrated in the Carnot Cycle. Therefore, fuel cells are more efficient in extracting electrical energy from a fuel. Scientists and inventors have designed many different types and sizes of fuel cells in the search for greater efficiency, and the technical details of each kind vary.

Problem areas associated with hydrogen fuel cells include long term supply and cost of platinum group catalysts, and the production, storage and distribution of hydrogen.

10-Year Outlook

Many of the choices facing fuel cell developers are constrained by the choice of electrolyte, the design of electrodes, for example, and the materials used to make them depend on the electrolyte.

Each type of fuel cell has advantages and drawbacks compared to the others, and none is yet cheap and efficient enough to widely replace traditional ways of generating power, such coal-fired, hydroelectric, or even nuclear power plants.



SOLAR FUELS

Current Status

While mostly experimental, solar-fuel technology converts light or heat from the sun into chemical energy without using photosynthesis or other mechanisms from living organisms. Artificial photosynthesis emulates photosynthesis in a non-living material system typically to oxidize water to oxygen gas and protons and then reduce the protons to hydrogen.

Solar thermochemical metal oxide cycles use the sun's heat to drive oxygen from a ceramic material and then use the oxygen-deficient material to extract oxygen from either water or carbon dioxide to produce energized chemical products, specifically hydrogen or carbon monoxide. Hydrogen or a mix of hydrogen and carbon monoxide (syngas) can be stored for later use and/or further reacted to produce liquid hydrocarbons, such as methanol, di-methyl-ether, gasoline, diesel, or aviation fuels. In this way, solar fuels are complementary to biofuels as they are low in water usage and do not require arable land. Like biofuels, solar fuels are an alternative to fossil fuels for use in transportation, generating electricity, or producing heat.

There are two ways that solar fuels could provide sustainable fuels for transportation. The first is using hydrogen to power hydrogen vehicles. The second is using a combination of hydrogen and carbon monoxide (referred to as synthesis gas, or syngas) to make liquid fuels (referred to as synthetic fuels) for transportation.

This conversion of syngas into synthetic fuels is called the Fischer-Tropsch process. Currently, synthetic liquid fuels are produced from gasification of coal (coal-to-liquids [CtL]), natural gas

(gas-to-liquids [GtL]), or biomass (biomass-to-liquids [BtL]) to syngas followed by Fischer-Tropsch processing and further refining to liquid fuels. A relatively near-term opportunity is to hybridize solar with natural gas, biogas, or biomass to make solar hybrid fuels with a lower carbon footprint than GtL or BtL.

Challenges

In the past, the predominant thinking of scientists, relative to carbon capture and sequestration, was to store it underground. Now scientists are considering the harvesting of CO_2, and efficiently recycling it to generate a liquid hydrocarbon fuel.

10-Year Outlook

With proper research, deployment, and scale-up, researchers estimate they could make a low-carbon, precisely equivalent replacement for gasoline, diesel, or jet fuel from solar fuels at a cost nearing $4 per gallon.

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7. CONCLUSION

For the first time in over two decades, Arizona has an executive energy guide that will serve as a reference point for the state's elected officials, industry, organizations, and citizens. Governor Janice K. Brewer's office established destinations achievable through pathways identified in the Executive Summary. These pathways were established through the comprehensive input given by a large number of individuals and organizations. The destinations are aggressive, achievable, and executive: increasing solar energy development, educating our next generation of energy professionals, making Arizona a leader in energy-sector workforce development, fostering statewide coordination to reduce energy consumption, and establishing a permanent Energy Advisory Board.

As the section, Arizona's Energy Resources makes clear, the solar potential in Arizona is immense. The technologies being developed and fine-tuned will ensure a growing solar-energy future for the state. The citizens, researchers and businesses of this state will lead the charge to an independent and advanced energy future, and the state can make the path to energy independence more certain. Arizona's government can eliminate redundant bureaucracy in its processes and implement best practices across its jurisdictions.

Addressing the gap in the energy workforce is paramount. Educating a new generation in energy literacy will be a boon to the economy of not only Arizona, but the United States. Our next generation will have a firm foundation that allows them to dream and implement energy technologies that today are unfathomed and enable them to realize job opportunities well into the 21st century. Many citizens in Arizona are currently looking for work and struggling to find it. The energy sector is a high-wage job industry requiring skilled labor and offering rewarding employment opportunities. Numerous entities around the state can unite to assist and inform those on the path to getting back to work. Arizona is home to prestigious universities and research institutions and can realize so much potential through partnerships.

When we assess our state's lands and resources, our logical conclusion is that our surest investment in Arizona's energy-generation future is to reduce energy consumption and therefore not have to build a new generation facility. Efficiencies level future demand and help the state preserve its natural resources of water and land. Arizona can be a leader in implementing energy-efficient technologies and procuring those technologies for its property.

In the process of compiling input for *emPOWER Arizona*, participants repeatedly agreed that the process of collaboration was both useful and worthwhile. Establishing an Energy Advisory Board will ensure that the channels of communication stay open among energy stakeholders into the future.

Arizona's energy and economic future should be determined by its people. With information comes power, and it is the ultimate goal of *emPOWER Arizona* that Arizona's private citizens, businesses, localities and organizations are empowered with energy information and given the opportunity to take the lead in the areas they see fit. Arizona is in the hands of its people; therefore, its best days will always lie ahead.

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8. CONTRIBUTORS

Revisions of the *2014 emPOWER ARIZONA: Executive Energy Assessment and Pathways* were approved by the 2014 State Energy Advisory Board based upon suggested updates by the Governor's Office of Energy Policy staff.

2014 STATE ENERGY ADVISORY BOARD

Advisory Board Chair – Leisa Brug, Director, Governor's Office of Energy Policy and Energy Policy Advisor to Governor Janice K. Brewer
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Senator Bob Worsley, Arizona State Senate
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Mark Bonsall, CEO, Salt River Project
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Commissioner Vanessa Hickman, Arizona State Lands
Jose Esparza, VP of Energy Solutions, Southwest Gas
Henry Darwin, Director, Arizona Department of Environmental Quality

2013 MASTER ENERGY PLAN TASK FORCE MEMBERS

Submitted by December 31, 2013, *emPOWER Arizona* was a collaborative effort by the Governor's Office of Energy Policy, Arizona Commerce Authority, Arizona Legislature, Arizona Corporation Commission and leading industry partners. The Arizona Master Energy Plan Task Force, established by an Executive Order in 2013, helped to develop the 2013 energy resource guide. The Task Force was divided into four work groups with a series of 16 meetings being held as well as four public meetings for additional input.

Task Force Chair – Leisa Brug, Director, Governor's Office of Energy Policy and Energy Policy Advisor to Governor Janice K. Brewer

Governor's Office of Energy Policy Staff: Olivia Doherty, Eric Fitzer, Adam McAnally and Jack Haenichen

Transportation, Fuels, and Infrastructure Planning
Subcommittee Chair – Rep. Frank Pratt, Arizona House of Representatives, Chairman Energy and Natural Resources Committee

Brad Albert – Arizona Public Service
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Note: *emPOWER Arizona* does not purport to be a reflection of all committee members' (or their employer's) opinions nor unanimity of members of the Arizona Master Energy Plan Task Force.

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9. GLOSSARY OF TERMS

ABO: Algae Biomass Organization
ABOR: Arizona Board of Regents
ACA: Arizona Commerce Authority
ACC: Arizona Corporation Commission
ACEET: Arizona Center for Energy Education and Training
ACT: Agricultural Consultation and Training
ADA: Arizona Department of Agriculture
ADEQ: Arizona Department of Environmental Quality
ADOA: Arizona Department of Administration
ADOT: Arizona Department of Transportation
AFB: Air Force Base
AG: Arizona Attorney General
AHJ: Authorities Having Jurisdiction
AMI: Advanced Metering Infrastructure
APS: Arizona Public Service
ASLD: Arizona State Land Department
ASU: Arizona State University
ATP3: Algae Testbed Public
AUTUM: Association of University Technology Managers
AZCIS: Arizona Career Information System
AZGS: Arizona Geological Survey
AZ-LEAD: Arizona Land Energy Assessment Dispensation
AZNRCD: Arizona Natural Resource and Conservation Districts
AzRISE: Arizona Research Institute for Solar Energy
AZTE: Arizona Technology Enterprise
AzWWG: Arizona Wind Working Group
BIA: U.S. Bureau of Indian Affairs
BLM: U.S. Bureau of Land Management
BOR: U.S. Bureau of Reclamation
BTA: Biennial Transmission Assessment
CAA: Clean Air Act of 1970
CAES: Collabatory for Advanced Energy Solutions
CAFE: Corporate Average Fuel Economy
CAISO: California Independent System Operator, an independent, nonprofit Independent System Operator (ISO), serving California.
CAP: Central Arizona Project

Carnot Cycle: The Carnot Cycle can be thought of as the most efficient heat engine cycle allowed by physical laws.

CBO: U.S. Congressional Budget Office

CCS: Carbon Capture and Sequestration

CH_4: Methane; main compound of natural gas

CO_2: Carbon dioxide, a colorless, odorless, nonpoisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes.

CSP: Concentrated Solar Power

DC: Direct Current

DES: Arizona Department of Economic Security

DOD: U.S. Department of Defense

DOE: U.S. Department of Energy

ECAP: Education Career Action Plan

ECoNA: Economic Collaborative of Northern Arizona

EGS: Enhanced Geothermal Systems

EIA: U.S. Energy Information Administration. An independent agency within the U.S. Department of Energy that develops surveys, collects energy data, and analyzes and models energy issues. The agency must meet the requests of Congress, other elements within the U.S. Department of Energy, Federal Energy Regulatory Commission, the Executive Branch, its own independent needs, and assist the general public, or other interest groups, without taking a policy position.

EIM: Energy Imbalance Market

EPA: U.S. Environmental Protection Agency

EPCs: Energy Performance Contractors

EMCC: Maricopa Community Colleges, Estrella Mountain Community College

ERIP: Energy Resource Integration Platform

ESCOs: Energy Savings Performance Contractors

EV: Electric Vehicle

FERC: Federal Energy Regulatory Commission

GOEP: Governor's Office of Energy Policy

GOWD: Governor's Office of Workforce Development

GPEC: Greater Phoenix Economic Council

GW: Gigawatt, 1 billion watts or 1,000 megawatts.

HERS: Home Energy Rating System

HURF: Highway User Revenue Fund

HOV: High-Occupancy Vehicle Lane

IECC: International Energy Efficiency Code

IGERT SUN: Integrative Graduate Education and Research Traineeship: Solar Utilization Network

IP: Intellectual Property

ISES: Institute for Sustainable Energy Solutions

JTEDs: Joint Technical Education Districts

KV: Kilovolts, 1,000 volts.

Kw: Kilowatt

kWh: Kilowatthour, measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for one hour. One kWh is equivalent to 3,412 British thermal units (Btu).

LEED: Leadership in Energy and Environmental Design

MEC: Mohave Electric Cooperative

MPG: Miles per gallon. "For each subgroup or "table cell," MPG is computed as the ratio of the total number of miles traveled by all vehicles in the subgroup to the total number of gallons consumed. MPGs are assigned to each vehicle using the EPA certification files and adjusted for on-road driving.

MTBE: Methyl tert-butyl ether; a fossil-fuel derived gasoline additive which raises the oxygen level in gasoline, similarly to ethanol and other oxygenates, to increase the octane number/rating.

MW: Megawatt, 1 million watts of electricity.

MWh: Megawatthour, 1,000 kilowatt-hours or 1 million watt-hours.

MY: Model year

NAU: Northern Arizona University

NEI: Nuclear Energy Institute

NEPA: National Environmental Policy Act

NERC: North American Reliability Corporation

NGS: Navajo Generating Station

NRC: Nuclear Regulatory Commission

NREL: National Renewable Energy Laboratory

NSF: National Science Foundation

NTUA: Navajo Tribal Utility Authority

OE: Office of Electricity Delivery and Energy Reliability

PACE: Property Assessed Clean Energy

PHEV: Plug-in hybrid electric vehicle

PSERC: Power Systems Engineering Research Center

PV: Photovoltaic solar

PVNGS: Palo Verde Nuclear Generating Station

R&D: Research and Development

RDEP: Restoration Design Energy Project

REAP: Rural Energy for America Program

REIDs: Renewable Energy Incentive Districts

REST: Renewable Energy Standard and Tariff

RETIP: Renewable Energy Tax Incentives Program

RTPs: Renewable Transmission Projects

SEP: State Energy Program

SFB: School Facilities Board

SMR: Small modular reactor

SPO: Arizona State Procurement Office

SRP: Salt River Project

STB: Surface Transportation Board

STEM: Science Technology, Engineering and Math

SSVEC: Sulphur Springs Valley Electric Cooperative

SWAT: Southwest Area Transmission, Subregional Planning Group

SWTC: Southwest Transmission Cooperative, Inc.

TEP: Tucson Electric Power

TEPPC: Transmission Expansion Planning Policy Committee

TLA: Tech Launch Arizona

TREO: Tucson Regional Economic Opportunities, Inc.

TRIF: Technology and Research Fund

TWh: Terawatthour, 1 trillion watt hours.

UA: University of Arizona

UASTP: University of Arizona Science Technology Park

UNS: UniSource Energy Corporation; parent company of Tucson Electric Power and UniSource Energy Services.

USDA: U.S. Department of Agriculture

USFS: U.S. Forest Service

USFWS: U.S. Fish and Wildlife Service

WECC: Western Electricity Coordinating Council

10. APPENDICES

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