Renewing Arizona's Economy

The Clean Energy Path to Jobs and Economic Growth

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Executive Summary

Investing in a clean, renewable energy supply for Arizona would generate thousands of new high-paying jobs, boost Arizona's economy, conserve scarce water supplies and improve public health.

Adopting a renewable energy standard to increase electricity generation from clean and renewable sources by at least 1 percent per year (reaching 10 percent of total electricity consumption by 2015 and 20 percent by 2020) would have a variety of benefits compared to business as usual. Between 2005 and 2020, investing in renewable energy would:

- **Create jobs**, increasing net employment by an annual average of 380 jobs per year, for a total of 6,100 person-years by 2020;
- **Increase wages** by a net annual average of $66 million, with a total net present value of $570 million;
- **Increase the gross state product (GSP)** by a net annual average of $200 million, with a net present value of $1.6 billion;
- **Help rural areas**, directly generating over $600 million in property taxes to fund education and other local government services;
- **Save water**, conserving a total of 23 billion gallons, enough to supply the residential needs of Phoenix for three-quarters of a year; and
- **Reduce pollution**; in the year 2020 annually avoiding emissions of:
  - o More than 11,000 tons of smog-forming nitrogen oxide (the equivalent of taking over 500,000 cars off the road);
  - o More than 9,000 tons of soot-forming sulfur dioxide (13 percent of 2000 emissions from electricity generation); and
  - o 8 million tons of global-warming inducing carbon dioxide (the equivalent of taking 1.5 million cars off the road).

Overall, renewable energy is an excellent investment that will provide strong returns for Arizona. At the cost of a few dollars a month, Arizona electricity consumers would lock in stable energy prices for 20 to 30 years (the life of a renewable energy installation), hedge against the risk of fossil fuel price increases, reduce demand and price for natural gas, and reduce the need for transmission infrastructure and increase reliability by shifting to distributed energy systems.

Investments in renewable energy, dollar for dollar, produce a greater net benefit for Arizona's economy than traditional technologies. According the Arizona Department of Commerce, more than half of all expenditures for energy now leave the state and are not reinvested in local economies. In 2000, Arizona exported $2.5 billion to purchase electricity and gas, plus nearly $3 billion for petroleum. In contrast, fuel for wind, solar and geothermal energy is free, and fuel for biomass energy can be grown at home. As a result, renewable energy keeps more money in the local economy, where it can have a greater impact.

Arizona is well positioned to power its economy with renewable energy. In terms of raw potential, renewable resources could produce almost double the amount of electricity the state currently uses. These resources include:

- **Solar Energy.** Arizona has more concentrated solar energy potential than any other state in the U.S., upwards of 100 million megawatt-hours annually (over 150 percent of Arizona's current annual demand).
- **Wind Energy.** Windy areas north and east of Flagstaff and east of Phoenix could generate 5 million megawatt hours of electricity every year (about 9 percent of Arizona's annual demand).
- **Geothermal Energy.** Tapping into the Earth's heat in the southern part of the state could provide another

Credit: Shell Solar

Construction workers prepare to install solar panels.

5 million megawatt hours of electricity each year.

- **Clean Biomass Energy.** Using crop wastes and landfill gas to generate electricity could generate 1 million megawatt hours of electricity annually.

The Arizona Corporation Commission (a board of elected officials who regulate Arizona's electric utilities) should build on the steps it has already taken to promote clean, renewable energy.

In 2001, the commission adopted a rule to require the state's utilities to produce 1.1 percent of their energy from renewable sources by 2007. In 2004, the commission initiated a public dialogue to evaluate the possibility of increasing the required percentage of clean energy.

In January 2005, staff advisors for the commission released a report recommending extending the renewable energy standard to 5 percent by the year 2015 and 15 percent by the year 2025, with 20 percent coming from solar sources and one-quarter from distributed energy sources. This path would produce benefits for the state. However, it does not fully take advantage of all of the opportunities to improve Arizona's economy, help rural areas, conserve water, improve public health, and protect the state from the economic impact of reliance on fossil fuels.

To capture more fully the benefits of renewable energy, Arizona officials should:

Adopt an Accelerated Renewable Energy Standard

The Arizona Corporation Commission should implement a program to increase our use of renewable energy sources—including wind, solar, geothermal, and clean biomass power—by at least 1 percent each year, resulting in 10 percent renewable energy by 2015 and 20 percent by 2020.

Ensure That Municipal Electric Utilities and Electric Districts Invest in Renewable Energy

Municipal electric utilities (including the Salt River Project) and electric districts are outside the jurisdiction of the Arizona Corporation Commission. Arizona's leaders should ensure that these entities participate in renewable energy deployment as well, since their participation will enhance benefits to the state.

Introduction

Arizona is uniquely suited to lead the way toward a future filled with clean and renewable energy. The state is home to a large number of skilled workers and high-tech expertise. It is also home to rich resources for solar and wind energy. In fact, Arizona sunshine is among the most intense and best-suited for electricity generation anywhere in the world.

To promote renewable energy development and build the foundation for a clean energy market, four years ago the Arizona Corporation Commission set a goal of reaching 1.1 percent of electricity sales from renewables by 2007. The goal, while modest, has been enough to give a boost to several renewable energy projects across the state.

Arizona Public Service Co. (APS) and the City of Prescott are teaming up to build one of the world's largest photovoltaic power plants. APS chose Prescott for its altitude, clear skies and cool temperatures, all of which improve solar efficiency. Over the next few years, APS will expand the plant to 5 megawatts, making it one of the world's largest.

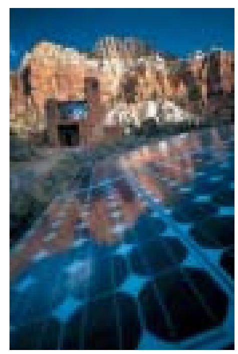


Photo: NREL

A little further southeast, Tucson Electric Power has begun to invest in new technology as well. The company recently expanded its Springerville solar photovoltaic power plant to 4.6 megawatts, enough to power 700 homes for a year. With excellent exposure to sunlight, the site is now the world's most productive solar facility.[1]

The question addressed in this report is: what would be the impact to the economy, consumers and public health of speeding the introduction of clean energy technologies to Arizona?

The answer: investing in clean energy would pay off handsomely for Arizona's economy. Renewable energy means more jobs, more wages, higher economic output, more water, less pollution, healthier people, and less flow of energy dollars out of state.

By accelerating the penetration of renewable energy into the electricity market,

Photo: Tucson Electric Power Co.

The Springerville Solar System.

the state can encourage investment in solar technology, wind turbines, geothermal plants, and all the manufacturing, installation, servicing and financing that go along with them. The effects will ripple outward through the economy, giving it a boost.

Investing in renewable energy will also create greater energy stability. Once renewable technologies have taken a foothold, the state will have a strong base of generating capacity from in-state sources, keeping more money in the state economy and reducing vulnerability to price shocks in natural gas, like those that contributed to California's energy crisis in 2001.

Building Arizona's renewable energy capacity would be a smart long-term investment in affordable and clean power for consumers. The time has never been better to invest in a clean energy future.

The Economic Development Potential of Renewable Energy in Arizona

Solar, wind, geothermal, and clean biomass technologies are often touted as clean and sustainable supplies of electricity. However, they are also an economic development tool that Arizona can use to move its economy forward, particularly in rural areas.

In this report we compare the economic and public health impacts of accelerating renewable energy development in the state with continuing business as usual. Specifically, we examine the outcome of increasing the use of renewable energy sources by at least 1 percent each year (resulting in 10 percent of electricity generation from renewable energy by 2015 and 20 percent by 2020). We define the impact of investing in clean energy sources like wind turbines and solar photovoltaic panels in comparison to a default path projected by the U.S. Energy Information Administration. We use an input-output economic model to describe how changes in spending affect the Arizona economy. See the Methodology section on page 33 for more details on the scenarios and assumptions involved.

Table 1: Net Impact of Accelerated Renewable Energy Development

Measure	Net Impact from 2005 to 2020
Jobs Created	6,100 person-years
Wages Paid	$570 million
Growth in Gross State Product	$1,600 million
Water Conserved	23 billion gallons
Avoided Smog-Forming NOx Emissions	67,000 tons
Avoided Soot-Forming SO2 Emissions	59,000 tons
Avoided Global Warming Pollution (CO2)	48 million tons

All impacts are above and beyond the business as usual case as forecast by the U.S. Energy Information Administration. All dollar figures are expressed in net present value terms and in 2002 values.

Table 2: Summary of Employment Impact

Measure	Net Impact from 2005 to 2020
Annual Average Jobs Created	380
Total Jobs Created through 2020	6,100 person-years
Annual Average Net Increase in Wages	$66 million
Net Present Value of Wage Increase through 2020	$570 million

Implementing an accelerated renewable energy standard would greatly benefit the economy and consumers in Arizona while conserving scare water supplies and reducing air pollution from power plants. Table 1 summarizes the results.

Employment Gains

Investing in renewable energy would create a net increase in jobs in Arizona. Compared to business as usual, accelerating the pace of renewable energy development in the state would create a net annual average of 380 jobs between 2005 and 2020 and increase overall wages paid in the state by an annual average of $66 million. (See Table 2.)

The majority of the new jobs created under clean energy policies would be well-paying jobs in the construction, electric utility and finance sectors of the economy. Clean energy policies produce more jobs than business as usual because they stimulate industries that are more effective at creating jobs than other parts of Arizona's economy. For example for every $1 million spent on construction in Arizona, 13.4 jobs are created. Alternatively, investing $1 million dollars on coal mining creates only 6.7 jobs.[2] (See Appendix for key economic multipliers derived for Arizona.) Moreover, renewable energy

Figure 1: Cumulative Employment Increase Due to Renewable Energy Investment

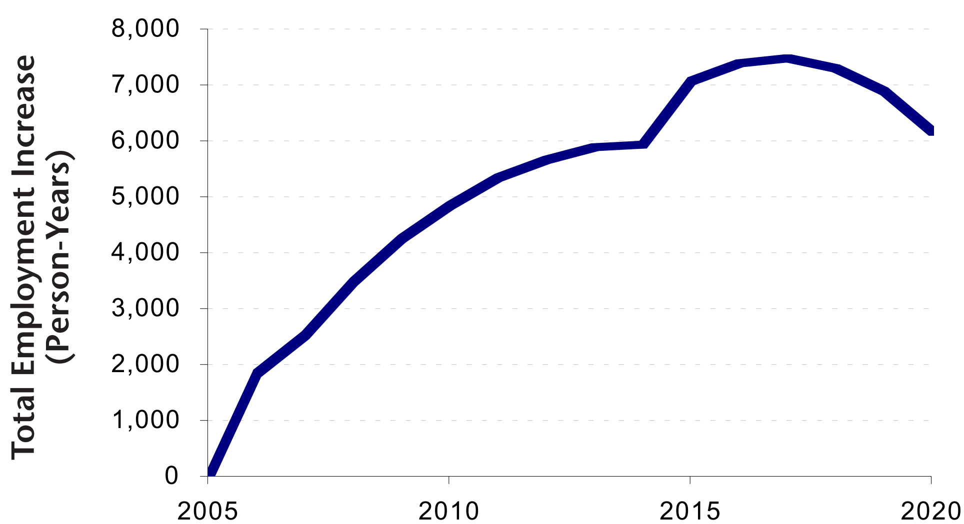
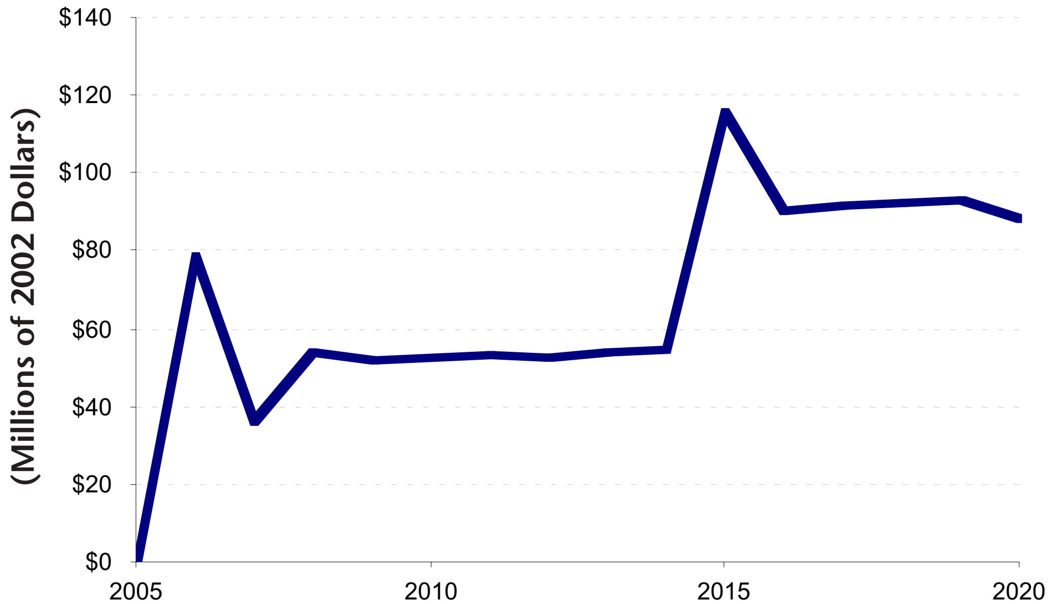


Figure 2: Annual Net Increase in Wages Paid Due to Renewable Energy Deployment



investments tend to stay in the local economy longer than investments in traditional technologies, because the fuel is free and much of the labor is local.[3] Currently, Arizona exports more than half of the money spent on natural gas and electricity out of state.[4]

Investing in clean energy also has indirect impacts on the economy because it reduces the demand for natural gas, thus reducing upward pressure on the price of this limited commodity. People end up having slightly more money in their pockets after paying their gas bills, which then can be spent in the local economy, creating more jobs.

Figure 1 shows the trajectory of the cumulative employment created by renewable energy investment, above and beyond the business as usual case. Figure 2 shows the year-by-year impact on net wages paid to workers in Arizona, implying a more rapid increase in the earnings of the average Arizona employee over time than would be created in the business as usual scenario. The increases in jobs and wages are driven by changes in spending patterns within the economy as a result of greater demand for renewable energy technologies.

Renewable Energy Creates Skilled, High-Paying Jobs

Investment in renewable energy directly creates quality jobs in manufacturing, construction, operation and maintenance, and finance.

Manufacturing

Manufacturing renewable energy systems requires highly skilled workers who design and build components of wind turbines, solar panels and other technologies.

Building a photovoltaic panel requires creating cells from silicon and glass, installing wires and other electrical components, and assembling them into a unit.

According to a 2002 analysis by University of California-Berkeley Professor Daniel Kammen, by the end of the decade, manufacturing a megawatt of solar photovoltaic panels will require nearly six full-time employees working for a year, given likely improvements in economies of scale and manufacturing technology.[5]

Similarly, much of the work involved in creating a wind farm goes into manufacturing the components, which include rotor blades, structural towers, hubs, transmissions, generators and assorted electronic controls. According to a survey of wind energy companies by the Renewable Energy Policy Project (REPP), manufacturing 10 MW of wind turbines requires a year of labor from 32 full-time workers.[6] The number of workers required will decline as the wind industry grows and becomes more efficient.

While much of the manufacturing work for renewable energy systems could happen out of state, Arizona has the potential to develop a powerful in-state renewable energy manufacturing industry that could take advantage of the regional and perhaps global renewable energy market. In particular, the Phoenix and Tucson areas have well-developed aerospace, semiconductor, and electronics manufacturing industries that could participate in a manufacturing boom for renewable energy technologies.[7] Proximity to a growing in-state renewable energy market, as well as to America's most concentrated solar energy resources (which lie along a belt from southern California to Texas) also make Arizona a potentially attractive location for manufacturing.

To take into account the fact that economic activity for manufacturing is not necessarily tied to Arizona, we assume that 60 percent of all expenses for renewable technology, including financing and ongoing operation and maintenance, will be local. Currently, just under 50 percent of all expenditures for electricity and natural gas remain in-state.[8]

Photo: NEG Micon

Workers assemble wind farm rotor blades.

Construction and Installation

Installation of renewable energy facilities typically involves local construction firms and general contractors, boosting local economies.

To install residential and commercial solar energy systems, a broad base of professional services are required, including engineering and design professionals, professional contractors and a network of distribution and support services not unlike those found with other mainstream construction industries. Dr. Kammen estimates that by the end of the decade, installing a megawatt of solar photovoltaic cells will support about four full-time workers for a year.[9] Wind farm installation also requires a large amount of local workers. Large wind farms can need up to 300 workers on site during construction. These workers assemble turbines, erect towers, pour concrete, build roads, and lay cable. Unlike traditional power

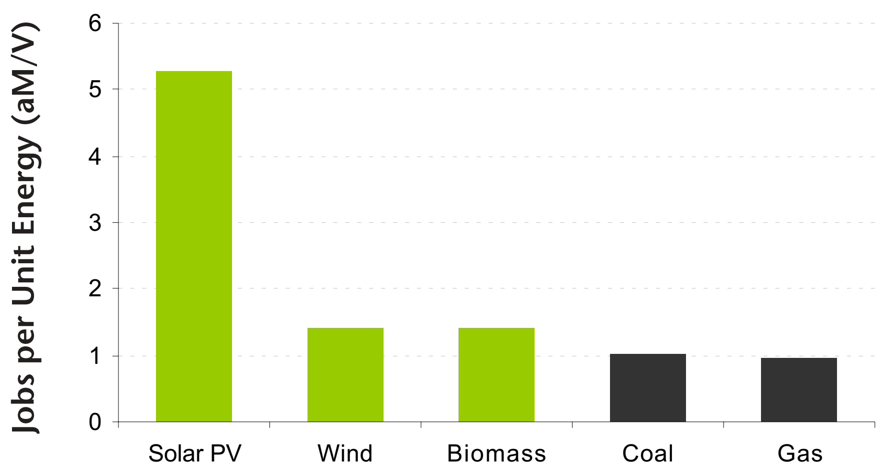
Renewable Energy Facilities Create More Jobs than Coal or Gas-Fired Power Plants

In total, renewable energy generates more jobs per unit energy produced than fossil-fuel technologies.[13] (See Figure 3.)

Investment in renewable energy also generates more jobs per dollar invested than investment in fossil-fueled plants. For example, the Renewable Energy Policy Project calculates that for every million dollars invested, the solar PV industry generates 5.6 jobs (over 10 years) and the wind industry generates 5.7 jobs, while over the same time period the coal industry only generates 4 jobs.[15]

Accounting for the fact that renewable energy technologies do not require exporting money out of state for fuel supplies gives them an even greater local advantage.

Figure 3: Jobs Per Unit of Energy from Renewable and Fossil Technologies[14]



plants, wind farms are built quickly, usually in a year or less.[10]

Operation and Maintenance

The operation and maintenance needs of a solar installation or a wind farm create permanent, high-quality local jobs ranging from servicing panels or turbines to accounting.

Solar photovoltaic panels, having no moving parts, require relatively little maintenance once they are installed. According to a survey by the Renewable Energy Policy Project, each megawatt of installed photovoltaic capacity requires about 20 hours of routine maintenance and repair per year.[11] Wind farms need staff to operate and regularly service the

Renewable Energy Can Stimulate Rural Economies

Local Jobs

Renewable energy installation can create jobs in rural parts of the state. Wind farms in particular are often located in places where local economies depend on farming, ranching, or resource extraction. Local jobs include construction and facility installation, operation and maintenance of the facility after it is constructed, and jobs induced by the additional money the workers spend in the local economy.

Landowner Royalties

Rural landowners who lease their property for a wind facility can create an additional source of income. Unlike the income from a typical harvest, payments from wind energy are steady and year-round. The Union of Concerned Scientists estimates a typical farmer or rancher with good wind resources could increase the economic yield of their land by 30-100 percent.[16]

Although wind farms occupy large areas, the actual physical footprint of each wind turbine is small. A landowner could lease up to 10 percent of his or her land area for the construction of wind turbines, while continuing to use the rest for other purposes. Lease terms vary, but they typically represent 2.5 percent of gross revenue from electricity sales.[17] Assuming a contract price for electricity generated from wind power of 3 ¢/kWh, a single 1.5 MW turbine would bring the landowner $3,285 each year.[18] In the case of land owned by a local government or Indian tribe, leasing income could be funneled into local schools and services.

Under the scenario evaluated in this report, energy produced by wind farms in Arizona through 2020 could supplement rural landowner income by $34 million, benefiting farmers, ranchers, local governments, Indian tribes and the federal government.

Local Tax Income

Renewable energy equipment raises the property tax base of a county, creating a new revenue source to support education and other local government services.

Increases in the tax base from installing renewable energy facilities will be largest in rural counties where the wind and solar resources are often greatest. Although the direct impact to the statewide tax base will be relatively modest, new wind farms and solar installations can make a big difference to small communities. For example, the installation of 400 MW of solar photovoltaic panels in Wellton would add about 11 percent to the Yuma County tax base, and installing 500 MW of wind turbines outside St. Johns would add roughly 6 percent to the local tax base in Apache County.[19]

Renewable energy facilities are taxed at 20 percent of their depreciated cash value under a state law active until 2012, an incentive to stimulate development of renewable energy sources.[20] Assuming that the law is not extended, the renewable energy development scenario evaluated here would funnel over $600 million into local government coffers through 2020.[21]

turbines throughout their roughly 30-year lifetimes. A recent survey of large wind farms in Texas found that every 100 MW of capacity requires six full-time employees to operate, monitor, and service the turbines.[12]

Finance

In contrast to traditional fossil-fuel technologies, renewable energy systems have large up-front costs followed by minimal ongoing expenses. Fossil fuel plants have much larger ongoing expenses for fuel, which is free in the case of solar, wind and geothermal energy. As a result, renewable energy projects require large loans up front. As the wind farm or solar energy plant generates electricity over time, it gradually pays off the initial debt. This expenditure creates jobs in the banking and finance sector.

Spillover Effects

Each dollar spent on renewable energy creates impacts that ripple outward through the local economy, extending far beyond the direct creation of jobs at energy facilities.

For example, workers at a manufacturing plant need raw materials and equipment. Their work in assembling turbines supports jobs in equipment manufacturing and component supply. Contractors at a construction site need concrete and heavy equipment, and their work supports additional jobs supplying these needs. In addition to these indirect jobs, workers spend some of their wages in the local economy, purchasing goods and services like groceries and housing and supporting additional workers.

Energy Price Effects

Renewable energy also has an impact by reducing the demand for other energy sources.

For example, renewable energy reduces demand for natural gas and slows the upward pressure on natural gas prices. As a result, people and industries that depend on natural gas will have slightly smaller bills than without natural gas conservation efforts. These savings can then be reinvested in other parts of the economy, rather than spent on high-priced fuel imported from out of state. This additional spending creates jobs throughout the economy.

Recent studies estimate that for every 1 percent reduction in national natural gas demand, natural gas prices fall by 0.8 percent to 2 percent below forecast levels.[22] A national renewable energy standard would produce natural gas bill savings with an estimated net present value as high as $73 billion from 2003 to 2020.[23] Reduced natural gas demand driven by state-level policy in Arizona would produce a more modest reduction in gas prices, but would still produce benefits for the state.

Photo: NREL

Farmers and ranchers can make additional income by leasing their land for wind farms.

Increased Economic Output

In addition to creating jobs and increasing wages paid in the state, accelerated renewable energy development would

A home fitted with rooftop solar panels.

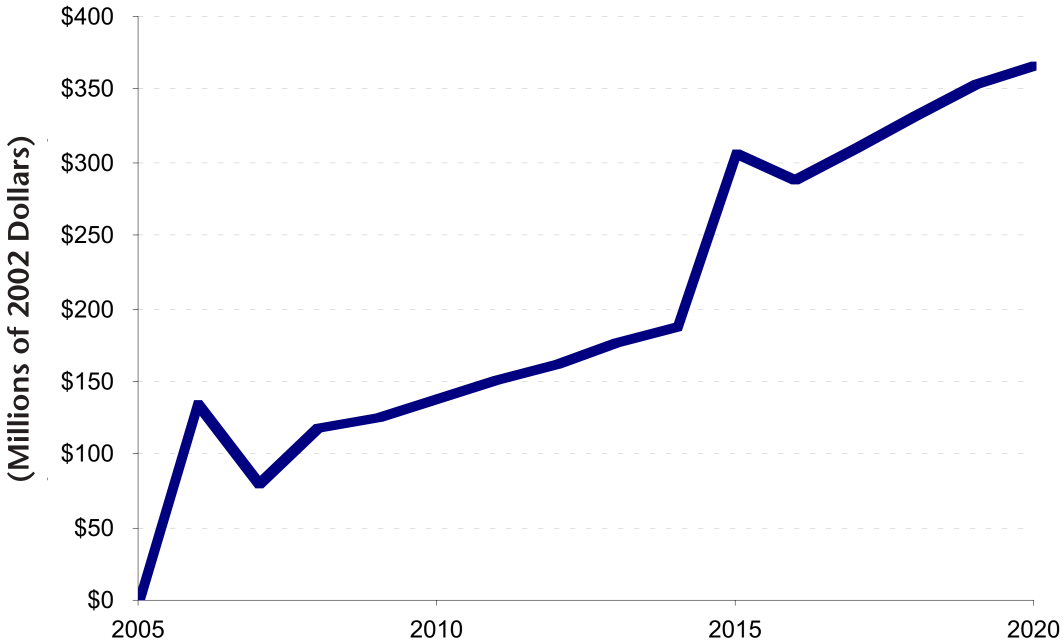
The Benefits of Solar Energy for Homeowners

Individual homeowners stand to benefit from increased use of solar energy. Several Arizona utilities have a policy of allowing the owners of solar photo- voltaic systems to sell electricity back to their utility through the electric grid.[24] Salt River Project and Tucson Electric Power allow home owners to run their electricity meters backward during periods when their solar system generates more electricity than they are using, crediting them for the energy they produce at full retail value. Arizona Public Service Co. allows solar owners to sell electricity back to the utility at a reduced price (the utility's avoided cost).[25] Home solar owners who benefit from these policies will pay smaller electricity bills over time. The money saved thus becomes available for other family needs and can be fed back into the local economy.

Electricity consumers who do not own solar panels also benefit from solar energy, because solar reduces peak demand for electricity during daylight hours. For example, one study of the electric system in the Mid-Atlantic region in the summer of 2000 found that the output of solar PV installations was worth 24 ¢/kWh in terms of the economic value of reducing peak load, effectively reducing the need to construct additional power plants. At the same time, the wholesale market price for electricity was 5 ¢/kWh.[26] In other words, solar PV helps to keep the price of electricity from spiking during periods of peak demand. Everyone who uses the electric grid shares in these benefits.

Customer-owned, customer-sited solar systems are also a good deal for ratepayers who contribute funds to a renewable energy development program. Through cost-sharing with customers, development dollars spent on these projects increase the potential for achieving broad penetration of solar technology into the market. Strong support for customer-based programs as a key component of a renewable energy standard will lead to broader success.

Figure 4: Annual Net Increase in the Gross State Product Due to Renewable Energy Investment



increase the overall economic output of the state. The renewable energy development scenario considered here would increase the gross state product (GSP) by an average of $200 million per year, with a net present value of benefits by 2020 of $1.6 billion. Figure 4 shows the trajectory of the annual impact on GSP over time, in constant 2002 dollars.

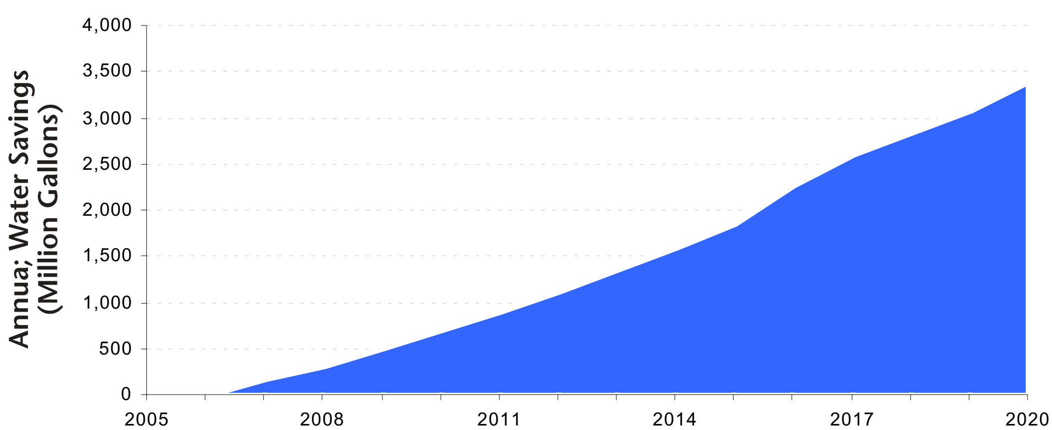
GSP is the traditional measure of basic economic activity within the state. It is a measure of the goods and services produced within the state in a given year. Clean energy policies improve the GSP because they increase the amount of money kept within the local economy. For example, one dollar invested in Arizona's electric utility sector creates $0.812 worth of economic output. Alternatively, one dollar invested in Arizona natural gas distribution creates $0.476 worth of output.[27]

Investments in renewable energy, dollar for dollar, produce a greater net benefit for Arizona's economy than traditional technologies. According to the Arizona Department of Commerce, more than half of all expenditures for energy now leave the state and are not reinvested in local economies. In 2000, Arizona exported $2.5 billion for electricity and gas, plus nearly $3 billion for petroleum.[28] In contrast, fuel for wind, solar, and geothermal energy is free, and fuel for biomass energy can be grown at home. As a result, renewable energy keeps more money in the local economy, where it can have a greater impact.

Table 3: Water Requirements of Energy Generation Technologies[31]

Energy Technology	Water Consumption (gallons per MWh)
Coal-fired simple cycle power plant, once-through cooling	290 to 320
Coal-fired simple cycle power plant, re-circulating cooling system	690
Natural gas combined cycle power plant, once-through cooling	100
Natural gas combined cycle power plant, re-circulating cooling system	180
Nuclear power	820
Solar PV, residential	Negligible
Solar PV, central utility	25
Solar Thermal[32]	1,100
Wind	Negligible
Biomass, once-through cooling	350
Geothermal (water is typically drawn from high-mineral content areas deep underground and is not suitable for other uses)	0 to 1,000

Figure 5: Estimated Annual Water Savings from Renewable Energy Use



Reduced Water Usage

Renewable energy has the additional benefit of conserving water. This benefit is especially important given the arid, dry climate of Arizona, and the growing demand placed on water supplies by a population growing at six times the national rate.[29]

Traditional power plants depend heavily on a constant supply of water to produce steam and provide cooling.[30] Some of the water is released to the atmosphere and irreversibly consumed, thus unavailable for other uses. In contrast, renewable energy technologies, with the exception of solar thermal power plants, use very little water. For example, water use for a central utility solar PV system is limited to that required to periodically wash dust off of the panels. Table 3 shows the consumptive water use of different types of energy systems.

Assuming that the average new fossil-fueled plant in Arizona would consume 300 gallons of water per MWh produced, the renewable energy scenario evaluated here would conserve more than 23 billion gallons of water between 2005 and 2020. (See Methodology for details on projected technology deployment.) To put that in perspective, the whole state of Arizona now uses about 20 trillion gallons of water in a typical year, more than three quarters of which goes to agriculture. A typical household in Phoenix uses around 180 gallons per day.

In other words, over the next 15 years renewable energy could save enough water to supply the residential needs of the half-million families in Phoenix for three-quarters of a year.[33] By 2020, the state would save enough water to supply the annual needs of 52,000 Phoenix-area households. Figure 5 shows the projected annual water savings.

Public Health Benefits

In addition to economic benefits and water conservation, investing in renewable energy could create a cleaner,

Photo: Kenn Kiser

A coal-fired power plant smokestack.

healthier future for the state. Our analysis did not capture all of the public health and environmental benefits resulting from clean energy development. However, we did examine how clean energy investment would affect power plant emissions of soot, smog and carbon dioxide.

The renewable energy development scenario considered here would significantly reduce soot and smog pollution, which damages public health; and reduce carbon dioxide emissions, the leading cause of global warming.

Reduced Pollution and Improved Public Health

Soot and Smog

Coal and natural gas-fired power plants emit air pollution. For every megawatt-hour of electricity generated, the average Arizona power plant emits one pound of soot-forming sulfur dioxide and two pounds of smog-forming nitrogen dioxide.

Sulfur dioxide forms fine soot particles in the atmosphere. When inhaled, these particles become lodged deep in the lungs where they cause a variety of health problems, including asthma, bronchitis, lung cancer and heart attacks.[34] Soot pollution from power plants is responsible for significant harm to public health in Arizona. According to a study by Abt Associates, a frequent consultant to the U.S. EPA, soot in Arizona causes nearly 2,000 asthma attacks and 11,000 missed work days due to respiratory illness.[35]

Fossil-fueled power plants also emit nitrogen dioxide, one of the primary ingredients in smog. Smog makes lung tissues more sensitive to allergens and less able to ward off infections.[36] It scars

Coal-fired Power and Mercury

Mercury emissions from coal-fired power plants and other industrial sources are making the fish in our lakes, rivers and streams unsafe to eat. Burning coal releases mercury into the air that eventually contaminates rivers and lakes, where bacteria convert it to a highly toxic form that bioaccumulates in fish. In 2000, Arizona's coal-fired power plants emitted over 1,400 pounds of mercury.[48]

Mercury is a neurotoxin that is particularly damaging to the developing brain. In early 2004, EPA scientists estimated that one in six women of childbearing age in the U.S. has levels of mercury in her blood that are sufficiently high to put one in six babies born each year at risk of learning disabilities, developmental delays and problems with fine motor coordination, among other problems.[49]

U.S. EPA tested fish across the country for mercury content in 1999. Of 35 largemouth bass caught in lakes in Arizona, 100 percent had unsafe levels of mercury contamination.[50] As a result, the Arizona Department of Environmental Quality has issued fish consumption warnings for 140 acres of lakes in the state.[51]

Renewable energy sources do not emit mercury pollution.

airway tissues.[37] Children exposed to smog develop lungs with less flexibility and capacity than normal. During high smog days, otherwise healthy people who exercise cannot breathe normally.[38] Over time, smog exposure can lead to asthma, bronchitis, emphysema and other respiratory problems.[39] Most of the Phoenix metro area does not meet federal health standards for smog.[40]

In contrast, solar, wind and geothermal energy do not emit pollution. As a result, displacing fossil-fueled energy sources to supply some of Arizona's future energy needs would reduce future emissions significantly:

- By 2020, the scenario evaluated here would reduce smog-forming nitrogen dioxide emissions by nearly 11,000 tons per year. This is the equivalent of removing over 500,000 cars from the road.[41]
- It would also avoid over 9,000 tons of soot-forming sulfur dioxide emissions, the equivalent of 13 percent of 2000 emission levels.[42]

Reduced Global Warming Pollution

Every megawatt-hour of electricity generated in Arizona produces 1,430 pounds of carbon dioxide, the leading culprit in global warming.

Global warming poses a serious challenge to Arizona's future. Pollution caused by the burning of fossil fuels is the chief culprit in raising the average temperature of the earth, posing severe potential threats to mountain snow-pack and the state's water cycle, grassland and forest ecosystems, and public health.

According to the U.S. Environmental Protection Agency, over the last century, the average temperature in Tucson has increased more than 3 degrees Fahrenheit.[43] Should the concentration of greenhouse gases continue to increase over the next century, temperatures could increase significantly. According to Jonathan Overpeck, the director of the University of Arizona's Institute for the Study of Planet Earth, some models predict an average temperature increase in the desert southwest of 10 degrees Fahrenheit or more.[44]

Arizona is already struggling with a long-term drought that has hurt its economy, costing the cattle ranching and related industries $2.8 billion in 2002.[45] The drought and changing weather patterns have drained the regions two biggest reservoirs, Lake Mead and Lake Powell, to half their full capacity.[46] Further alterations in water supplies, forests, grasslands and other ecosystems could cause further severe disruptions in society.

The renewable energy deployment scenario evaluated here could reduce carbon dioxide emissions by 8 million tons annually by 2020, the equivalent of retiring 1.5 million cars from the road.[47]

Nuclear Waste

Spent nuclear fuel is one of the most dangerous substances ever created by mankind. It remains highly radioactive for hundreds of thousands of years and would cause extensive public health damage if released into the air after an accident or terrorist attack.

Arizona's Palo Verde nuclear power plant burns through 200 nuclear fuel assemblies every year, producing roughly 50 tons of nuclear waste with no safe way to dispose of it.[52] The federal government has proposed disposing of high-level waste at Yucca Mountain in Nevada. Even without the considerable safety issues raised by shipping the waste on public highways and the fact that Yucca Mountain can not safely contain the waste until it is no longer dangerous, this solution faces political obstacles that may well prove insurmountable.

Renewable energy does not produce nuclear waste.

Impact on Electricity Consumers

Developing clean energy supplies would be accompanied by a gradual increase in the price of electricity, offset by reduced upward pressure on the price of natural gas used by industry and in the home. Overall, the net annual consumer investment would average $260 million. For the average residential customer, this will translate into an average increase in monthly energy costs of $3.70. (See Appendix for a detailed chart of estimated impact on residential electricity bills.)

Several factors must be kept in mind while interpreting this cost increase. First, this increase is projected against forecasts partially based on natural gas prices from the Energy Information Administration (EIA) that are optimistic at best. Recent EIA projections have underestimated the rise in natural gas prices; current prices, for example, are significantly higher than those projected by EIA for the next 15 years.[53] The natural gas spot market is notoriously volatile, and there is no indication current prices will decline.

Natural gas prices have doubled since the mid-1990s, and are not likely to decline anytime soon. Limitations in supply coupled with increased demand could keep prices persistently high, and even brief interruptions in supply can cause wild price swings. Production of natural gas in the U.S. has not kept up with increased demand. Between 1989 and 2002, natural gas consumption in the U.S. increased by 17 percent. During the same period, domestic production of natural gas increased by only 10 percent, while the number of producing gas wells in the U.S. increased by 40 percent.[54] In short, more wells are being drilled, each well is producing less gas, and consumption – particularly in the electric sector – continues to increase. The overall economic cost of the natural gas crisis between 2000 and 2004 has been estimated at as much as $111 billion.[55] While future imports of liquid natural gas (LNG) from overseas may help to keep prices lower than they would be if we depend solely on domestic production, LNG itself is subject to a variety of problems that could lead to price impacts, including vulnerability to accidents or terrorist attacks and increased dependence on potentially unstable areas of the world for energy imports.

In contrast, renewable energy comes with a price guarantee, and will help shield the state from spikes in natural gas prices, such as those triggered during the California energy crisis in 2001.

Overall, renewable energy is an excellent investment that will provide strong returns for Arizona. At the cost of a few dollars a month, Arizona electricity consumers would lock in stable energy prices from renewable sources, hedge the risk of fossil fuel price increases, reduce demand and price for natural gas, and through the use of distributed energy, reduce the need for transmission infrastructure and increase electric system reliability.

Balanced Energy Policy and Energy Efficiency

Policies encouraging energy efficiency should also be a part of a balanced energy supply mix. Reducing demand has the same effect on the supply/demand balance as increasing supply, but without the negative impacts of energy production and use. According to the Alliance to Save Energy, energy efficiency measures implemented since the 1970s have reduced our energy use by 40% from what it would have been. This has translated into energy bills at least 40% lower.

In most cases, demand management options are also cheaper and faster to implement than supply-side options. The California Public Utility Commission calculated that energy efficiency programs administered by the state's utilities from 1994–97 came at an average cost of 1.6 ¢/kWh, about a third of the typical cost of energy from new fossil fuel power plants.[56] And while large fossil-fired power plants take 2–5 years to get online, savings from conservation measures can be realized in months. These savings can last as long as or longer than new power plants in the case of durable equipment and buildings.

There are great opportunities for energy conservation and energy efficiency improvements in each of the main sectors of energy use — transportation, industrial processes, and buildings & appliances. Vehicle manufacturers have made great strides in fuel economy technology, yet have not brought many of these technologies to market. Industry is slowly integrating whole system design into their factories and using more efficient motors and pumps. Building codes and appliance standards have the potential to greatly reduce energy consumption in commercial and residential buildings. Energy conservation and efficiency programs also benefit consumers. After the initial expense of purchasing better appliances or installing better meters that allow them to use energy more wisely, consumers benefit from smaller utility or fuel bills. Research by the RAND Corporation has shown that energy efficiency improvements over the last 25 years have saved Californians billions of dollars — up to $1,300 per person — and gave the entire state economy a 3% boost.[57]

From Here to There: A Scenario for Clean Energy Deployment in Arizona through 2020

Arizona is experiencing rapid growth in population and energy use. The Energy Information Administration (EIA) forecasts 2.5 percent annual growth in electricity sales in the region through the next decade and a half.[58]

If we do not act decisively, Arizona could pass up the potential to grow its economy through renewable energy and instead meet additional demand with more unstable, dirty and dangerous sources of electricity, despite the problems they create. Arizona currently generates almost all of its electricity from traditional technologies, including coal-fired, natural gas-fired or nuclear power plants. In fact, Arizona generators produce 50 percent more than in-state needs, and export electricity to other states, aggravating local environmental problems. (For details, see Appendix.)

Well-designed energy efficiency programs in Arizona and other nearby states could mitigate demand growth or even level it off completely. However, even with efficiency programs in place, Arizona will need new power sources to eventually replace dirty coal-fired power plants and dangerous nuclear plants as they are retired.

In this report we examine the outcome of meeting about two-thirds of Arizona's projected growth in electricity consumption (as predicted by the EIA) with renewable energy technology. (See Figure 6.)

Tapping Into Arizona's Renewable Energy Resources

Arizona is blessed with a large amount of untapped renewable energy resources, including more solar energy potential than any other state in the U.S. and good potential for wind power. In terms of raw potential, renewable resources could produce almost double the amount of electricity the state currently uses.

These resources include over 300 days per year of concentrated sunshine, areas with high average wind speed and areas in the southern half of the state where geothermal heat rises relatively close to the surface of the earth. As shown in table

4, Arizona's clean energy resources have the potential to produce over 100,000 GWh per year of electricity, while electricity sales in the state currently reach around 55,000 GWh per year.[59]

Table 4: Arizona's Renewable Energy Resources[60]

Energy Source	Electricity Generation Potential (GWh / year)
Solar	101,000
Wind	5,000
Geothermal	5,000
Biomass	1,000

Solar Energy

In terms of raw resources, Arizona is the solar energy capital of the United States. With over 300 days per year of sunshine and a dry, arid climate, Arizona is ideally suited for generating electricity from the sun.

There are two major solar energy technologies used to generate electricity: solar photovoltaic cells (solar PV), and solar thermal systems.

Solar PV technology takes the energy of the sun's rays and transforms it directly into electricity. Flat-plate solar PV systems can be installed in a centralized power system managed by a utility company, or mounted on the rooftops of homes and buildings distributed across an urban area. PV cells can even be built into building materials like roofing or siding. Some solar PV systems use concentrating lenses to increase the energy of the light reflected on the cells before turning it into electricity.[61]

Solar thermal systems use the sun's heat to generate electricity. Sunlight, sometimes concentrated by mirrors, heats a liquid that is then used to move a piston or turbine and generate electricity. California has nearly 10 operating solar thermal power plants using parabolic

Figure 6: A Scenario for Renewable Energy Deployment

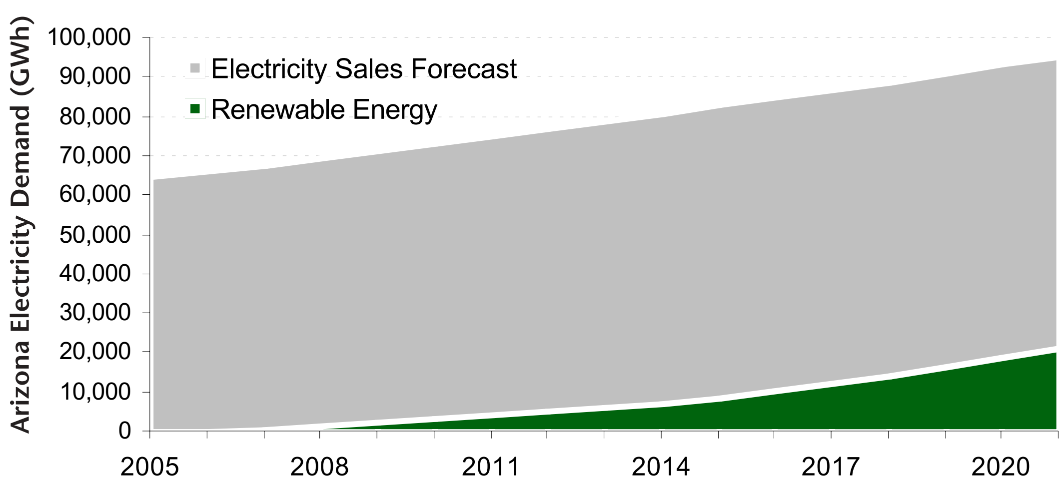


Photo: NREL

A solar-thermal power plant.

trough mirrors to focus sunlight on columns of liquid. Arizona Public Service Co. just installed a similar facility north of Tucson. Other types of solar thermal power plants include large power towers with a field of mirrors and smaller-scale dish systems with Stirling engines. Future solar thermal systems will achieve increased efficiency and output through the use of energy storage systems that allow electricity generation even during periods of low sunlight.[62]

Solar power in Arizona has the potential to produce over 100,000 GWh of electricity per year.[63]

Wind Energy

Arizona has moderate wind resources, concentrated north and southeast of Flagstaff, as well as in the Kingman area.

Wind energy is harnessed with wind turbines, which can be hundreds of feet tall and reach generation capacities of 1.5 MW or more. Modern wind turbines take advantage of technology from lightweight aerospace materials to innovative low-speed generators. New innovations continue to improve their efficiency and will enable the effective use of wind in areas with slower average wind speeds in the near future.[65]

Wind energy could produce up to 5 million MWh per year in the state. [66]

Biomass and Geothermal Potential

Biomass and geothermal together hold modest potential to supply electricity in Arizona, up to 6 million MWh per year.

Geothermal systems use the earth's heat to generate electricity. The most common geothermal systems tap underground reservoirs of hot water to generate steam, turn a turbine, and produce electricity. Suitable locations for geothermal plants are characterized by relatively shallow access to the earth's heat and are found most frequently in the southern half of the state.[68] These resources could generate as much as 5 million MWh of electricity per year.

The category of biomass encompasses many types of "waste-to-energy" technologies and energy crops used to generate electricity. As an arid state with relatively little agriculture, biomass in Arizona has correspondingly low potential as an electricity source. However, Arizona could profit from burning landfill methane to generate electricity, instead of allowing it to leak into the atmosphere, where it acts as a potent global warming gas. Other opportunities exist to use crop byproducts as fuel. Altogether, biomass in the state could produce about 1 million MWh of electricity per year.[69]

Some types of biomass technologies should not be considered clean or renewable, including municipal solid waste, rubber tire and construction debris incinerators, which can release dangerous pollutants from the combustion of plastics and chemicals. For a definition of acceptable biomass fuels, please see page 39.

Figure 7: Annual Solar Radiation Intensity in the Southwest – Ideal for Solar Power[64]

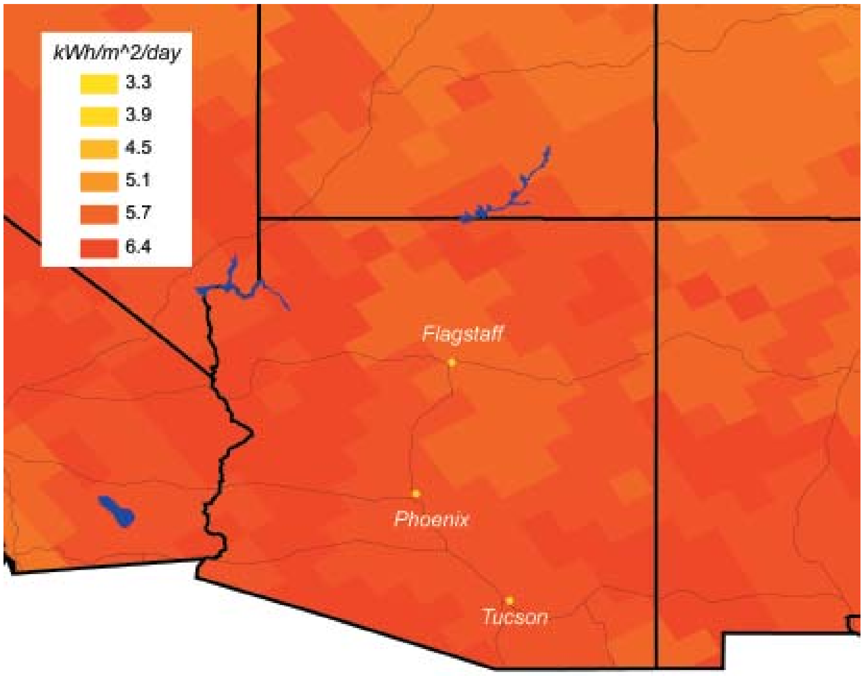
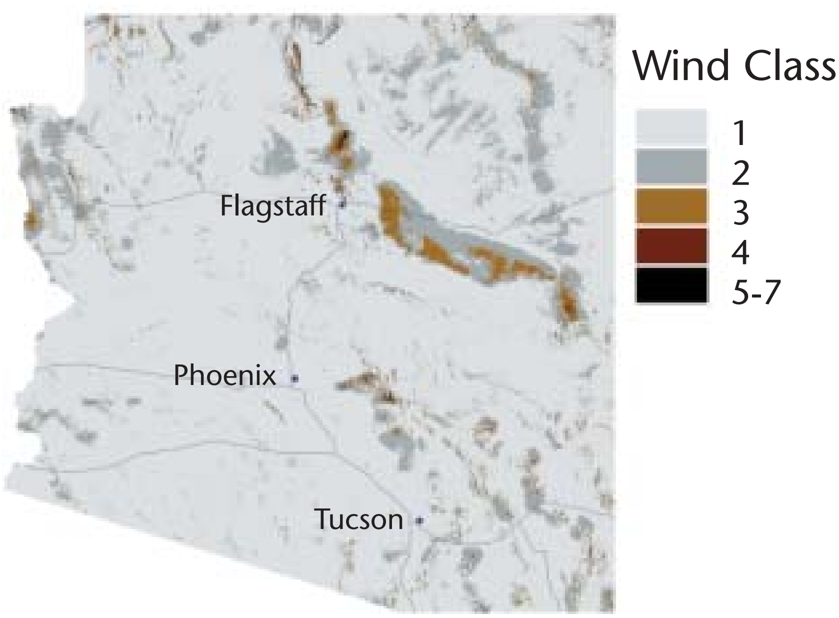


Figure 8: Wind Energy Resources in Arizona[67]



A site with wind class four or above is well-suited for a wind turbine, while new technologies promise to make class three sites more accessible in the near future.

Policy Recommendations: Renewing Arizona's Economy

Investing in renewable energy would give a boost to Arizona's economy, create thousands of jobs and increase wages, and save water, all while improving public health.

The Arizona Corporation Commission (a board of elected officials who regulate Arizona's electric utilities) has taken several steps to promote clean, renewable energy, but much more remains to be done.

In 2001, the commission adopted a rule to require the state's utilities to produce 1.1 percent of their energy from renewable sources by 2007. Last year, the commission initiated a public dialogue to evaluate the possibility of increasing the required percentage of clean energy.

In January 2005, staff advisors for the commission released a report recommending extending the renewable energy standard to 5 percent by the year 2015 and 15 percent by the year 2025, with 20 percent coming from solar sources and one-quarter from distributed energy sources. This path would produce benefits for the state. However, it does not fully take advantage of all of the opportunities to improve Arizona's economy, help rural areas, conserve water, improve public health, and protect the state from the economic impact of reliance on fossil fuels.

To capture more fully the benefits of renewable energy, Arizona officials should:

1. Adopt an Accelerated Renewable Energy Standard

The Arizona Corporation Commission should implement a program to increase our use of renewable energy sources, including wind, solar, and geothermal power, by at least 1 percent each year, resulting in 10 percent renewable energy by 2015 and 20 percent by 2020.

A clean energy standard set at this level would be reasonable and achievable. It would create economies of scale, spur innovation, and establish dedicated markets to support the deployment of renewable energy technologies and diversify Arizona's electricity supply. Renewable energy industries would be able to build from this initial boost to achieve higher levels of market penetration with less assistance in the future.

Arizona's current modest renewables requirement does not have an enforcement provision. Utilities that fail to meet the requirement face no consequences. The accelerated program should have accountability provisions to ensure that utilities meet the requirement.

The renewable energy standard should also ensure that unacceptably dirty or dangerous forms of energy are not included. For example, municipal solid waste incineration should not be included in the definition of "biomass" or considered renewable.

Finally, the renewable energy standard should require utilities to acquire all cost-competitive renewable energy resources when searching for new capacity to meet electricity demand. In other words, the renewable energy standard should not act as a cap on renewable energy development.

Four of the states that border Arizona have already taken similar steps to kick-start their renewable energy markets and realize the economic development, public health and environmental potential of renewable power. Most recently, Colorado voters passed a renewable energy standard in the 2004 elections, ensuring that their electric utilities will invest in cleaner energy supplies and improve the rural economy. Nevada has passed a renewable energy standard that increases 2 percent per year through 2013, with a strong program to promote solar energy. New Mexico recently set a renewable energy standard of 10 percent by the year 2011. Finally, California has the most aggressive renewable energy program in the United States, and is moving to take advantage of a global market for clean energy technology.


Photo: C. Dec

Arizona should join these states with an accelerated plan to invest in clean, renewable energy.

2. Ensure Municipal Electric Utilities and Electric Districts Invest in Renewable Energy

Municipal electric utilities (including the Salt River Project) and electric districts are outside the jurisdiction of the Arizona Corporation Commission. **Arizona's leaders should ensure that these entities participate in renewable energy deployment on an accelerated schedule as well, since their participation will enhance the benefit to the state.**

Methodology

The Arizona PIRG Education Fund developed an Arizona-specific energy and economic model to project the specific economic and public health impacts of renewable energy deployment on an accelerated schedule. The model employs input-output economic principles and is based on statistics that describe the production and exchange of goods and services within the various sectors of the Arizona economy, as provided by the Minnesota IMPLAN Group, Inc. (MIG), with all dollar results reported as the equivalent of 2002 values.[70] When selecting assumptions, we consciously chose conservative values, and the results are generally consistent with a large number of state-level studies that have been carried out previously.[71] This approach allows a meaningful comparison of baseline projections of energy consumption and prices with changes driven by clean energy policies.[72]

Establishing the Default Path

We first established a baseline forecast for energy development in Arizona from 2005 to 2020. This default path served as the point of comparison with the clean energy alternative.

In general, the baseline forecast was established using the most recent statistics from the U.S. Energy Information Administration (EIA) for Arizona's electricity sector, forecast to 2020 using the trajectory set in the regional tables of EIA's Annual Energy Outlook 2004.[73] For example, EIA forecasts a 2.5 percent annual growth rate for electricity sales in the mountain region, which, when applied to Arizona, yields the electricity sales forecast shown in Figure 6.

We made similar forecasts for electricity prices, natural gas consumption, coal consumption, power plant heat rates and power plant environmental performance, based on EIA data.

Macroeconomic forecasts for Arizona under the business as usual path, including GSP, employment and wages, were calculated from EIA's *Annual Energy Outlook 2004*, scaled to Arizona using the state and U.S. economic forecasts published by Woods and Poole Economics, Inc.[74] In general, EIA forecasts assume that future electricity needs will be supplied by a mixture of current fossil-fired technologies and new fossil technologies like gasified coal.

We additionally assume that the Palo Verde nuclear power plant will remain operational during the time frame of the forecast and that no additional nuclear plants will be installed.

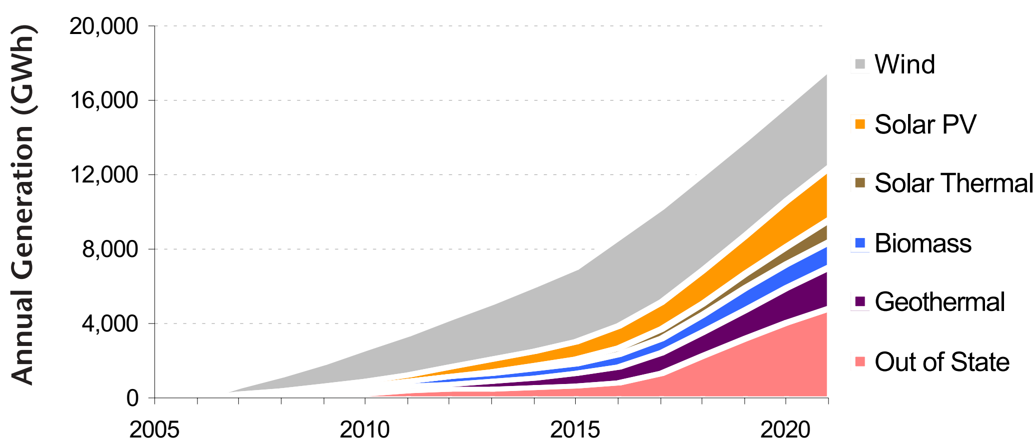
Describing the Clean Energy Scenario

We developed a plausible scenario for clean energy deployment that would be driven by a renewable energy standard requiring 10 percent of electricity sales to come from clean and renewable sources by 2015 and 20 percent by 2020. The scenario assumes the following:

- Solar technologies will initially supply 8 percent of the required renewable energy and gradually increase to 20 percent of the required renewable energy as the technologies mature and costs decline;
- Wind energy resources will be developed relatively quickly until production reaches 5 million MWh per year.
- Biomass and geothermal generation will increase until production reaches roughly 1.5 million MWh/year and 2 million MWh/year, respectively.
- The balance of resources will come from out of state, because given available transmission, only some low-cost renewable energy could be imported into Arizona to meet the standard; and
- Capital costs and operation, maintenance and fuel costs of each technology will decline as the technologies mature.[75]

Figure 9 graphs the development of a mix of technologies stimulated by the clean energy standard. Future growth beyond this point would be dominated by solar energy technologies, which would have excellent momentum after the initial stimulus driven by the clean energy standard. To the extent that technology advancements in wind power allow development of areas with slower average wind speeds, wind power could play an expanded role in Arizona's future as well.

Figure 9: Arizona Clean Energy Scenario



Modeling the Impact of Clean Energy Development in Arizona

Renewable energy deployment would require a change in investments in technology, energy prices, energy expenditures, and program costs. We estimated these expenditures based on the anticipated capital, operations, maintenance and fuel costs for renewable energy technologies. We then mapped the change in expenditures and prices into the IMPLAN-derived state energy and economic model to estimate macroeconomic impacts as compared to the baseline "business as usual" scenario. Investment in renewable energy supplies based in other states was assumed to have zero impact on the Arizona state economy. For a more complete description of the state-specific models from which the Arizona-specific model was derived, see the short working paper, "Modeling State Energy Policy Scenarios," available from PIRG.[76]

Key Assumptions

Key assumptions used in the economic modeling are as follows:

Generation Costs:
See Table below.

Local Impacts:
To take into account the fact that economic activity for manufacturing is not necessarily tied to Arizona, we assume that 60 percent of all expenses for renewable technology, including financing and ongoing operation and maintenance, will be local.

Local Program Spending	**0.60**
Local Investment	**0.60**
Local Respending /Savings Ratio	**0.75**

Price Dynamics:
We assumed that the renewable energy standard would have the effect of reducing upward pressure on the price of natural gas, and reducing the price for coal. However, since prices for these fuels are set by a regional and national market, while the policy affects fuel demand only in Arizona, the impacts are much smaller than those for a national renewable energy standard as described on page 17. To the extent that other states adopt renewable energy standards and reduce their fuel demand, it will have positive impacts on Arizona's economy. The effect of policies established in other states or at the federal level are not modeled in this report.

Generation Costs	Renewables	Utility Base	New Fossil Technology (eg. Clean Coal)
Investment ($/kW)	$1,120	$700	$1,200
O&M ($/kWh)	$0.012	$0.008	$0.006
Fuel Cost ($/kWh)	$0.008	$0.017	$0.014
Capacity Factor	0.305	0.52	0.8
Heat Rate (Btu/kWh)	n/a	9600	9200
Learning Rate per year	0.98	0.98	0.98
Initial Cost ($/kWh)	$0.082	$0.048	$0.045
Air Emissions Rate	0%	100%	18.2%

Appendix

Note On Electricity Units

Megawatts (MW) are the standard measure of a power plant's generating capacity, or the amount of power it could produce if operating at full speed. Utilities measure their ability to supply demand on the grid at any one time in terms of MW. One MW equals 1,000 kilowatts (kW). One thousand MW equals one gigawatt (GW).

Power plant output and electricity consumption over a fixed length of time are measured in terms of megawatt-hours (MWh). For example, a 50 MW power plant operating at full capacity for one hour produces 50 MWh of electricity. If that plant operates for a year at full capacity, it generates 438,000 MWh of electricity (50 MW capacity x 8,760 hours/year). To give a sense of scale, an average household uses about 10 MWh of electricity each year.

Most plants do not operate at full capacity all the time; they may be shut down for maintenance or they may be operated at only part of their maximum generating potential because their power is not needed or their power source (such as wind) is not available. The actual amount of power that a plant generates compared to its full potential is reported as its capacity factor. Thus a 50 MW plant with a 33 percent capacity factor would produce 144,540 MWh of electricity in a year (50 MW x 8,760 hours/year x 33% capacity factor).

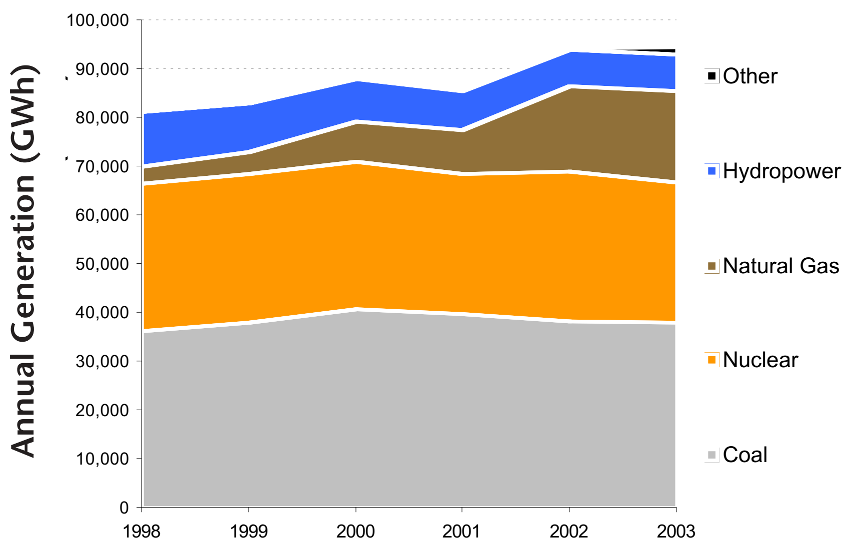
Arizona's Current Electricity Mix

Over 99% percent of Arizona's electricity comes from dirty, dangerous, and unsustainable sources, including large hydropower dams and power plants fueled by coal, natural gas, or radioactive uranium.

Figure 10 shows the fraction of the state's electricity supplied by different energy sources over the last seven years. As shown in the figure, coal-fired power plants remain the largest source of electricity in the state, accounting for 40 percent of all generation. The Palo Verde nuclear power plant ranks as the second-largest source of electricity, generating 30 percent. Since 1998, natural gas has become a much more significant part of the state's energy mix, now accounting for 20 percent of electricity generation. Hydropower generation produces about 8 percent of the state's electricity. Only 1 percent of electricity comes from other sources, including renewable energy technologies.

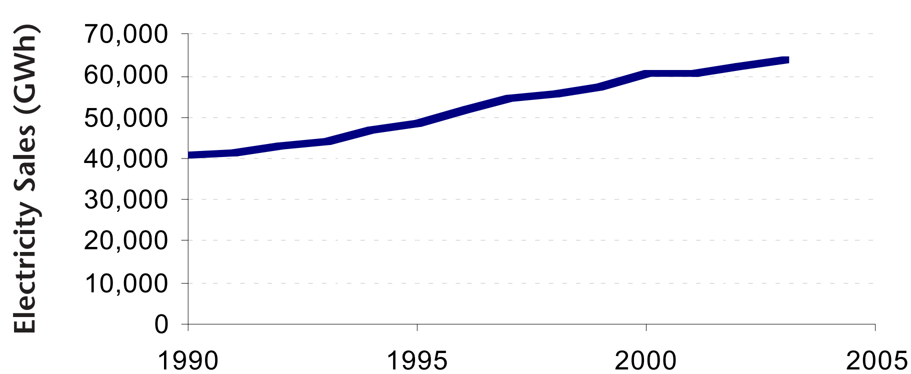
Arizona generates roughly 50 percent more energy than it needs. The excess energy is exported to neighboring states. However, electricity use within Arizona has been climbing rapidly, faster than in-state electricity generation. Arizona's electricity demand climbed 3.9% between 1993 and 2002, as compared to 2.1% for in-state generation during the same period.[78] (See Figure 11). The sales growth scenario used in this report follows a more modest 2.5% annual growth rate in electricity sales.

Figure 10: Sources of Arizona's Electricity from 1998 Through 2003[77]



Over 99% of Arizona's electricity comes from fossil fuels, nuclear power, or harmful large dams. In the last five years, natural gas has become a significant source of electricity in Arizona, exposing consumers to greater fluctuations in energy prices due to dwindling supplies.

Figure 11: Historical Growth in Arizona Electricity Demand



Economic Impacts of Renewable Energy: Detailed Tables

Table A1: Economic Impacts of Renewable Energy Development Scenario by Year

Year	Total Net Jobs Created (Person-Years)	Increase in Wages Paid (Net Present Value, Million 2002 Dollars)	Increase in Gross State Product (Net Present Value, Million 2002 Dollars)	Cumulative Water Savings (Billion Gallons)
2005	0	$0	$0	0.0
2006	1,863	$69	$118	0.0
2007	2,529	$99	$183	174
2008	3,496	$140	$273	500
2009	4,253	$177	$363	1,017
2010	4,873	$212	$455	1,739
2011	5,367	$246	$550	2,655
2012	5,696	$277	$644	3,793
2013	5,903	$306	$740	5,162
2014	5,961	$334	$836	6,774
2015	7,098	$389	$982	8,633
2016	7,420	$430	$1,110	10,914
2017	7,508	$468	$1,239	13,527
2018	7,340	$504	$1,368	16,383
2019	6,926	$537	$1,496	19,481
2020	6,165	$567	$1,620	22,882

Table A2: Public Health and Consumer Impacts of Renewable Energy Development

Year	Total NOx Emissions Avoided (Tons)	Total SOx Emissions Avoided (Tons)	Total CO2 Emissions Avoided (Million Tons)	Estimated Increase in Energy Costs for the Average Residential Electricity User (2002 $/month)
2005	0	0	0.0	$0.00
2006	0	0	0.0	$0.72
2007	531	479	0.3	$1.07
2008	1,489	1,337	1.0	$1.55
2009	2,955	2,654	1.9	$2.00
2010	5,006	4,492	3.3	$2.43
2011	7,600	6,839	5.0	$2.84
2012	10,762	9,714	7.1	$3.22
2013	14,503	13,093	9.7	$3.61
2014	18,877	17,017	12.7	$3.98
2015	23,909	21,489	16.3	$4.78
2016	30,117	26,996	20.8	$5.40
2017	37,525	33,441	26.3	$6.00
2018	46,085	40,930	32.6	$6.57
2019	55,769	49,321	40.0	$7.12
2020	66,666	58,641	48.4	$7.62

Key Economic Multipliers for Arizona

Table A3: Type 1 Multipliers for the Arizona Economy[79]

SECTOR	Type I Multiplier Employment (Per $MM of Final Demand)	Type I Multiplier Compensation (Per Dollar of Final Demand)	Type I Multiplier Value-Added (Per Dollar of Final Demand)	Labor Productivity Growth (Percent/ Year)
Agriculture	16.2	0.332	0.755	1.54%
Oil and Gas Extraction	11.4	0.188	0.626	2.66%
Coal mining	6.7	0.364	0.750	2.66%
Other Mining	8.4	0.379	0.798	2.66%
Electric Utilities	3.9	0.256	0.812	2.80%
Natural gas distribution	5.1	0.241	0.476	3.40%
Construction	13.4	0.467	0.708	2.00%
Manufacturing	8.3	0.416	0.647	2.30%
Wholesale trade	9.9	0.473	0.886	1.50%
TPU	13.6	0.542	0.784	2.80%
Retail Trade	19.5	0.489	0.900	1.50%
Services	17.0	0.463	0.837	0.40%
Finance	10.6	0.421	0.800	1.50%
Government	11.5	0.504	0.945	0.40%

Definition of Clean Biomass

Some technologies categorized as "biomass" are actually toxic and should be avoided, including waste and tire incineration. Arizona PIRG Education Fund considers the definition of clean biomass to be:

A. Any plant-derived organic matter available on a renewable basis

B. Non-hazardous plant matter waste material that is segregated from other waste materials and is derived from:

   1. an agricultural crop, crop by-product or residue resource

   2. waste such as landscape or right-of-way tree trimmings or small diameter forest thinnings, but <u>not including:</u>

      a. municipal solid waste

      b. recyclable post-consumer waste paper

      c. painted, treated, or pressurized wood

      d. wood contaminated with plastic or metals

      e. tires

C. Gasified animal waste

D. Digester gas

E. Biogases and biofuels derived, converted or processed from plant or animal waste organic materials

F. Landfill methane.

Any biomass combustion must meet the best available control technologies for emissions. Preference should be given for gasified biomass technologies.

Notes

1. Tucson Electric Power Company, *Greenwatts*, (Real Time Display of Springerville Output), available at www.greenwatts.com, viewed on 19 February 2005.

2. Multipliers derived from: Minnesota IMPLAN Group, 2002 Data for the State of Arizona, Stillwater, Minnesota, 2005.

3. For example, Arizona consumes 600 times more natural gas than it produces: U.S. Department of Energy, Energy Information Administration, *Arizona Natural Gas Summary*, downloaded from EIA's Natural Gas Navigator at www.eia.doe.gov on 19 February 2005.

4. Mark Hope, Arizona Department of Commerce, *2000 Energy Dollar Flow Analysis for the State of Arizona*, August 2002.

5. Daniel Kammen and Kamal Kapadia, *Employment Generation Potential of Renewables to 2010*, 2002.

6. Renewable Energy Policy Project, *The Work That Goes Into Renewable Energy*, November 2001.

7. Center for Business Research, Arizona State University, for the Arizona Department of Commerce, *High-Technology Activities in Arizona*, September 2003.

8. See note 4.

9. See note 5.

10. Texas SEED Coalition and Public Citizen, *Renewable Resources: The New Texas Energy Powerhouse*, September 2002.

11. See note 6.

12. See note 10.

13. Reports using a variety of methods and conditions all reach the same conclusion. See Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, University of California, Berkeley, *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* 13 April 2004; see also Skip Laitner and Marshall Goldberg, for Land and Water Fund of the Rockies, National Renewable Energy Laboratory and Arizona State Energy Office, *Arizona Energy Outlook 2010, Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy*, July 1997.

14. Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, University of California, Berkeley, *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* 13 April 2004.

15. See note 6.

16. M. Brower, et al., Union of Concerned Scientists, *Powering the Midwest: Renewable Electricity for the Economy and the Environment*, 1993.

17. Lease payments range between 2% to more than 10% of yearly gross revenues, depending upon competing land uses (National Wind Coordinating Committee, *The Effect of Wind Energy Development on State and Local Economies*, Wind Energy Series #5, January 1997, available at www.nationalwind.org); an assumed lease payment of 2.5% is common (see National

Wind Coordinating Committee, *The Effect of Wind Energy Development on State and Local Economies*, Wind Energy Series #5, January 1997; AWEA, Texas SEED Coalition and Public Citizen, *Renewable Resources: The New Texas Energy Powerhouse*, September 2002).

18. AWEA estimates that Pennsylvania farmers could earn $2000-$3000 per turbine per year, possibly assuming smaller capacity turbines. AWEA, *Wind Energy Is Good for Pennsylvania's Economy*, downloaded from www.awea.org/pennsylvania/documents/economy_pa.PDF, 15 February 2004.

19. Assuming that the facilities are installed at 2005 prices, that 25% of the value of the facility is taxable, and that the tax incentive cited in note 20 is applied. In 2000, Apache County had a net assessed primary valuation of $324 million and Yuma County had a net assessed primary valuation of $537 million. Arizona Department of Revenue, *2000 Annual Report*.

20. Arizona Revised Statutes, Section 42, Chapter 14, Title 155.

21. Tax income is reported in $2002 dollars, representing total payments from 2005 through 2020. The value reported here follows from the renewable energy development scenario described in the methodology section and assumptions that each facility depreciates on a linear schedule over a 25 year useful life, that 25% of market value is the assessed value, and that the average property tax rate is 12.5% of the assessed value per year. Market value is 20% of the depreciated cash value through 2011. After 2011, valuation reverts to the standard applied to other electricity generating facilities: in the first four years the market value is a fraction of the depreciated cash value: 35% in year one, 51% in year two, 67% in year three, 83% in year four, and 100% in the following years. See Arizona Revised Statues, Section 42, Chapter 14, Titles 151 to 158.

22. Ryan Wiser, Mark Bolinger and Matt St. Clair, U.S. Department of Energy, Lawrence Berkeley National Laboratory, *Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency*, LBNL-56756, January 2005.

23. Ibid.

24. For details, see Database of State Incentives for Renewable Energy, www.dsireusa.org.

25. National Conference of State Legislatures, *Energy and Electric Utilities, Energy Efficiency and Renewable Energy, Arizona State Fact Sheet*, 2004.

26. William Marcus and Greg Ruszovan, JBS Energy, Inc., prepared for the National Association of Energy Service Companies and Pace Law School Energy Project, *Mid-Atlantic States Cost Curve Analysis*, 18 September 2002.

27. Minnesota IMPLAN Group, 2002 Data for the State of Arizona, Stillwater, Minnesota, 2005.

28. See note 4.

29. Juliet Eilperin, "Arid Arizona Points to Global Warming as Culprit," *The Washington Post*, 6 February 2005.

30. Ellen Baum, et al. Clean Air Task Force and the Land and Water Fund of the Rockies, *The Last Straw: Water Use by Power Plants in the Arid West*, April 2003.

31. Ellen Baum, et al. Clean Air Task Force and the Land and Water Fund of the Rockies, *The Last Straw: Water Use by Power Plants in the Arid West*, April 2003; Ole von Uexküll, Rocky Mountain Institute, *Exploring The Relationship Between Energy and Water*, RMI Newsletter, Spring 2005; based on PH Gleick, "Water and Energy" *Annual Review of Energy and Environment* 19:267–299, 1994.

32. Figures apply to the Luz System type of solar thermal power plant.

33. Phoenix-area households use about 180 gallons per day of water, and the city of Phoenix hosts 465,834 households; Household figure derived from the U.S. Census Bureau, 2000 Census data for Phoenix.

34. C. Pope et al., "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution," *Journal of the American Medical Association* 287: 1132-1141, 2002; A. Peters et al., "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction," *Circulation* 103: 2810-2815, 2001; J. Samet et al., The United States Health Effects Institute, *The National Morbidity, Mortality, and Air Pollution Study, Part II: Morbidity and Mortality from Air Pollution in the United States*, Research Report Number 94, June 2000; Joel Schwartz, "Particulate Air Pollution and Chronic Respiratory Disease," *Environmental Research* 62: 7-13, 1993; D. Abbey et al., "Long-term Ambient Concentrations of Total Suspended Particles, Ozone, and Sulfur Dioxide and Respiratory Symptoms in a Nonsmoking Population," *Archives of Environmental Health* 48: 33-46, 1993; Joel Schwartz et al., "Particulate Air Pollution and Hospital Emergency Room Visits for Asthma in Seattle," *American Review of Respiratory Disease* 147: 826-831, 1993;

J. Schwartz et al., "Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children," *American Journal of Respiratory Critical Care Medicine* 150: 1234-1242, 1994.

35. Abt Associates, *Power Plant Emissions: Particulate Matter-Related Health Damages and the Benefits of Alternative Emission Reduction Scenarios* (June 2004).

36. M. Gilmour et al., "Ozone-Enhanced Pulmonary Infection with *Streptococcus Zooepidemicus* in Mice: The Role of Alveolar Macrophage Function and Capsular Virulence Factors," *American Review of Respiratory Disease* 147: 753-760; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine* 21: 1-48, 2000.

37. M. Lippman, "Health Effects of Ozone: A Critical Review," *Journal of the Air Pollution Control Association* 39: 672-695, 1989; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine* 21: 1-48, 2000.

38. W. McDonnell et al., "Pulmonary Effects of Ozone Exposure During Exercise: Dose-Response Characteristics," *Journal of Applied Physiology* 5: 1345-1352, 1983.

39. R. McConnell et al., "Asthma in Exercising Children Exposed to Ozone: A Cohort Study," *The Lancet* 359: 386-391, 2002.

40. Arizona Department of Environmental Quality, *Air Quality Plans: 8-Hour Ozone*, downloaded from www. www.azdeq.gov on 31 March 2005; Arizona Department of Environmental Quality, *Time Line for Maricopa County Nonattainment Area State Implementation Plan (SIP) Actions under the Clean Air Act Amendments of 1990*, Revised 24 June 2004.

41. Calculation based on a model year 2000 vehicle with a NOx emission rate of 38.2 pounds per year: U.S. Environmental Protection Agency, *Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks*, April 2000.

42. 2000 emission levels of NOx: over 100,000 tons; 2000 emission levels of SO2: over 70,000 tons; Source: U.S. Environmental Protection Agency, *E-Grid Database*, Version 2.01, May 2003.

43. U.S. Environmental Protection Agency, *Global Warming-State Impacts: Arizona*, Office of Policy, Planning, and Evaluation, September 1997.

44. Mitch Tobin, "A Warmer Arizona and Southwest Chill Scientists to the Bone," *Arizona Daily Star*, 16 February 2005.

45. See note 29.

46. Ibid.

47. Calculation based on a model year 2000 vehicle with a carbon dioxide emission rate of 11,450 pounds per year: U.S. Environmental Protection Agency, *Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks*, April 2000.

48. U.S. Environmental Protection Agency, *E-Grid Database*, Version 2.01, May 2003.

49. Kathryn R. Mahaffey, Robert P. Clickner, and Catherine C. Bodurow, "Blood Organic Mercury and Dietary Mercury Intake: National Health and Nutrition Examination Survey, 1999 and 2000," *Environmental Health Perspectives* 112 (5), 562-570, April 2004; Kathryn R. Mahaffey, U.S. EPA, Methylmercury: Epidemiology Update, presentation before the Fish Forum, San Diego, January 2004.

50. U.S. PIRG Education Fund and Clear The Air, *Reel Danger: Power Plant Mercury Pollution and the Fish We Eat*, August 2004.

51. USPIRG Education Fund, *Fishing for Trouble*, *How Toxic Mercury Contaminates Our Waterways and Threatens Recreational Fishing*, June 2003.

52. 200 fuel assemblies: Arizona Public Service Co. *2003 Environmental Health and Safety Report*, downloaded from www.pinnaclewest.com/main/pnw/AboutUs/commitments/ehs/2003/environmental/emissions/reporting/default.html on 17 February 2005.

53. EIA projects an even trajectory for wellhead natural gas prices, beginning at $3.50 (2002 dollars) per thousand cubic feet, and rising gradually to $4.01 in 2014 and $4.40 in 2025. However, in December 2004, prices reached $5.84 in 2002 dollars, already well above projections. Annual prices have exceeded the 2025 projection since 2003. Projections: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2004 with Projections to 2025*, January 2004; Actual Prices: U.S. Department of Energy, Energy Information Administration, *U.S. Natural Gas Prices*, Accessed through the Natural Gas Navigator on 3 March 2005, available at www.eia.doe.gov.

54. Consumption from Energy Information Administration, U.S. Department of Energy, *Annual Energy Review 2002*, 24 October 2003, Table 6.5. Production and number of producing wells from Energy Information Administration, U.S. Department of Energy, *Natural Gas Navigator*, accessed February 2004.

55. Paul Cicio, Industrial Energy Consumers of America, *41 Month Natural Gas Crisis Has Cost U.S. Consumers Over $111 Billion*, 19 December 2003.

56. California Public Utilities Commission, Office of Ratepayer Advocates, *The Public Purpose Energy Efficiency Surcharge: Trends and Patterns in the Costs and Benefits of Utility Administered Energy Efficiency Programs*, 8 March 2000.

57. RAND Corporation, *The Public Benefit of California's Investments in Energy Efficiency*, March 2000.

58. U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2004 with Projections to 2025*, Supplemental Table 8: Energy Consumption by Source and Sector (Mountain), January 2004.

59. Energy Information Administration, U.S. Department of Energy, *Current and Historical Monthly Retail Sales, Revenues, and Average Revenue per Kilowatthour by State and by Sector*, downloaded from www.eia.doe.gov/cneaf/electricity/page/data.html on 16 February 2005.

60. Land and Water Fund of the Rockies, Northwest SEED, Greeninfo Network, *Renewable Energy Atlas of the West: A Guide to the Region's Resource Potential*, 2002.

61. U.S. Department of Energy and the Electric Power Research Institute, *Renewable Energy Technology Characterizations*, Chapter 6, December 1997.

62. Ibid.

63. See note 60.

64. Map generated using data from the National Renewable Energy Laboratory, downloaded from www.nrel.gov/gis on 15 February 2005.

65. See note 61.

66. See note 60.

67. See note 64.

68. See note 60.

69. Ibid.

70. See note 27.

71. See e.g., Argonne National Lab and Environmental Protection Agency, Engines of *Growth: Energy Challenges, Opportunities, and Uncertainties In the 21st Century*, January 2004, available at www.4cleanair.org/ members/committee/ozone/EnginesofGrowth.pdf; Environment California, *Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California*, July 2003; Kammen, D., and Kapadia, K., University of California, Berkeley, *Employment Generation Potential of Renewables to 2010*, 2002; Hewings, G., Yanai, M., Learner, H., et al., Environmental Law and Policy Center, *Job Jolt: The Economic Impacts of Repowering the Midwest*, 2002; Tellus Institute, *Clean Energy: Jobs for America's Future*, October 2001; Union of Concerned Scientists, *Renewing Where We Live: A National Renewable Energy Standard Will Benefit America's Economy*, 2002 and 2003; Skip Laitner and Marshall Goldberg, for Land and Water Fund of the Rockies, National Renewable Energy Laboratory and Arizona State Energy Office, *Arizona Energy Outlook 2010, Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy*, July 1997.

72. For an overview of how this methodology might be typically applied, see Laitner, S., Bernow, S., and DeCicco, J., "Employment and Other Macroeconomic Benefits of an Innovation-Led Climate Strategy for the United States." *Energy Policy*, Volume 26, Number 5, April 1998, pp. 425-433. For an example of a study that applies this same modeling exercise within a state level analysis, see, Nadel, S., Laitner, S., Goldberg, M., Elliott, N., DeCicco, J., Geller, H., and Mowris, R., American Council for an Energy Efficient Economy, *Energy Efficiency and Economic Development in New York, New Jersey, and Pennsylvania*, Washington, DC, 1997.

73. Energy Information Administration, U.S. Department of Energy, *Individual State Data: Arizona*, downloaded from www.eia.doe.gov/emeu/states/main_az.html, 19 February 2005; Energy Information Administration, U.S. Department of Energy, *Annual Energy Outlook 2004 with Projections to 2025*, Supplemental Tables: (Mountain Region), January 2004.

74. Woods & Poole Economics, *Arizona: 2004 Data Pamphlet*, Washington, DC, 2004.

75. See note 61.

76. *Modeling State Energy Policy Scenarios*, a working document prepared for U.S. PIRG by Economic Research Associates, Alexandria, VA, January 2005.

77. Data derived from: U.S. Department of Energy, Energy Information Administration, *Form EIA-906 and EIA-920 Databases*, January - December 2003, downloaded from www.eia.doe.gov on 17 February 2003.

78. Energy Information Administration, U.S. Department of Energy, *State Electricity Profiles 2002: Arizona*, available at www.eia.doe.gov.

79. See note 27.

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