Economic Development Opportunities for Arizona in National Clean Energy and Climate Change Legislation

The Landsward Institute
Northern Arizona University
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NORTHERN ARIZONA UNIVERSITY

----------Executive Summary

Arizona's economy would benefit significantly from the implementation of an aggressive, nationwide clean energy development and climate change mitigation policy. Arizona stands to gain high-paying engineering, manufacturing and technology research and development jobs by implementing state policies to encourage investment in clean energy technology in Arizona. The development of low-carbon or renewable energy sources alone, which could take place in Arizona over the next 10-15 years, as a response to these types of policies, will generate:

- tens of thousands of construction-phase jobs and more than $10 billion in earnings and economic activity, &
- more than 4000 permanent jobs and $750 million annually in earnings and additional economic activity.

This development could take place in all regions of the state, and largely will be concentrated in rural areas. Impacts are likely to be spread across the state in proportion to the availability of the products and services that these developments require.

Over the last decade, Arizona has been one of the fastest-growing states in the nation. Additionally, Arizona is an energy exporter. That is, the state generates more electricity each year than Arizona customers require. Much of this electricity generation is from combustion of fossil fuels. Arizona, however, also lies in an area of the continental United States that will be impacted soonest, most directly, and most extremely by climate change.

The physical effects of climate change on the state likely will include drought, heat waves, wildfires, and an increase in extreme weather events (Field et al. 2007). The economic impacts on Arizona of these effects will include increased costs for water, electricity generation, air conditioning and industrial cooling, and pest management in the state's agricultural and forested areas.

Arizona has much to gain from rapid action on climate change. It is reasonably well-positioned to take advantage of these economic opportunities. The state has the best developable solar energy resource in the nation, and its solar supply chain and green-technology sectors have been growing rapidly, even during the current period of economic recession. State incentives and federal stimulus funds have combined to attract several new renewable energy and energy efficiency component manufacturing or corporate facilities to the state in 2009 alone. Increased attention to renewable energy has led to the establishment of dozens of small renewable-energy businesses, and the expansion of others, throughout the state. The increase in solar component manufacturers and company headquarters in Arizona will dramatically increase the indirect and induced impacts of investments in solar energy development, and the same is true for other renewable energy and energy efficiency technology development and manufacturing.

Arizona has renewable energy research programs at all three of the state's universities, and houses the headquarters of the nation's largest thin-film solar panel manufacturer and largest small-wind turbine manufacturer. The state has incentives in place to attract additional firms, and has reasonable transportation infrastructure. Arizona has outstanding solar energy resources, and has developable wind, geothermal, and biofuel resources. In addition, Arizona has a Climate Change Action Plan, has performed a greenhouse gas (GHG) emissions inventory, and has defined policy initiatives to accelerate its path to a lower-carbon economy.

Proposals to mitigate the impact of climate change center around different strategies to reduce the emissions of GHGs including carbon dioxide. Multiple studies have predicted the impacts of a nationwide GHG mitigation program on the nation's economy and on the well-being of families at a nationwide, regional, and state level. The results of these studies vary widely in their forecasts of energy costs, carbon prices, future electricity generation mix, and impacts on household well-being. When considering these studies collectively, however, it is clear that reducing the

costs of energy and climate legislation to America's families will depend in large part on the nation's ability to develop resources and technology to reduce emissions from industry and electricity generation.

Much of the economic modeling of the impacts of carbon pricing strategies on the economy shows negative net impacts on households. This is intuitive, because these models introduce new costs and compare a system with these costs to a system without these costs. In general these models do not forecast the economic impacts of not imposing a carbon price; that is, the models do not describe the negative impacts on the nation's economy of the physical effects of climate change. In addition, these models do not include the potential economic growth that will result from a new economic focus on low-carbon or no-carbon technologies. Studies that do include the economic development potential involved in shifting to a low-carbon economy show positive effects for the introduction of carbon pricing schemes.

While aggressive energy and climate change legislation undoubtedly will reduce future demand for coal-fired generation, an increase in demand for renewable, natural gas, and nuclear power generation will create thousands of construction-phase jobs and hundreds of permanent operation jobs in Arizona. Multiple reports have projected the millions of new renewable energy and energy efficiency jobs being developed nationwide (Werner 2008). Several studies quantifying the jobs related to renewable energy and energy efficiency capacity have shown that these types of development generate more jobs than other energy-related industry sectors, and that an aggressive national renewable energy/efficiency standard could generate more than 4 million job-years by 2030 (Wei et al. 2010).

Renewable energy development will occur with or without a national renewable energy policy, because a majority of states (including Arizona) have Renewable Energy Standards. Some of this development, particularly of solar energy resources, will occur in Arizona, but much of it will occur in whatever areas have the best resources and most attractive development policies. A nationwide climate change mitigation program, however, will increase demand nationwide for renewable energy resources, because "carbon pricing" will render fossil-fuel generation more expensive, and nuclear power development is slow and costly to implement. Thus, a nationwide climate change mitigation and clean energy program will increase the demand for Arizona's solar, wind, geothermal and biofuel resources, and increase research, development and demonstration opportunities for these resources in the state.

Nationwide climate change mitigation legislation will impact the cost of energy and goods, but it will do so in a more uniform fashion than regional initiatives, thus leveling the impact on the nation's families and reducing competition among regions. Reducing GHG emissions nationwide is critical to Arizona's continued prosperity, and the state is well-positioned to take full economic advantage of the opportunities national clean energy legislation presents.

Economically, Arizona should promote the development of a low-carbon economy, including low-emissions electricity generation and low-carbon technology development and manufacturing. Support for nationwide clean energy and climate change mitigation legislation will start this process, but state policies should be used to encourage this development. Examples include: streamlining permitting processes across agencies and jurisdictions statewide; providing additional incentives to low-carbon energy developers or manufacturing companies; establishing mechanisms to provide equal or equivalent incentives to renewable energy development or low-carbon industries located on tribal land or under tribal ownership; and establishing a state clean energy development agency to coordinate with research institutes, industries, government agencies and energy developers.

Background

Multiple strategies are under development to reduce emissions of greenhouse gases (GHGs) to mitigate the impacts of climate change. From municipal governments to the recent Copenhagen accord, emissions reduction strategies have been and continue to be defined in public policies. Selected faculty and student researchers at Northern Arizona University (NAU) performed an analysis of the potential economic impacts on Arizona of a United States clean energy and climate change mitigation policy similar to that contained in several proposed pieces of legislation in the United States Congress.

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Scope and Methods

The scope of this study is to discuss the potential impacts on Arizona's economy of a nationwide policy to reduce the emission of GHGs that contribute to climate change and increase the use of renewable and low-carbon energy sources and technologies. Specifically, this study identifies changes in electricity generation in the state that would result. The costs and benefits of such changes are estimated as they impact the people of Arizona, from a statewide perspective and on a county-level basis where appropriate, in terms of direct changes in employment, indirect and induced effects. In addition, the impact of an increased focus on low-carbon energy and technology on Arizona's economy, in terms of technology and manufacturing jobs, is discussed, and case studies are presented. Environmental impacts are not considered.

The principal methodology for this study included compiling and interpreting relevant data from sources including: existing research on the energy-sector impacts of various climate change mitigation programs; the Arizona Corporation Commission; principal Arizona electric providers; the Arizona Department of Commerce; the Energy Information Administration; and results from economic models, including the National Renewable Energy Laboratory (NREL) Jobs and Economic Development Impacts (JEDI) models.

Data from the sources listed above were used to generate a series of assumptions regarding trends in Arizona's electricity generation future, and each of these trends was modeled in terms of its effects on jobs, earnings, and economic output for direct, indirect, and induced impacts on the state's economy.

This study gathered statistics on historical and current electricity generation and employment in the electricity generation sector in the state. Using the resource planning documents of several of the state's utilities, this study identified likely trends in electricity generation in response to new climate change and energy legislation. This study used the NREL JEDI model to quantify the changes in employment that would result from these trends. This study also calculated the indirect economic impacts of each scenario of new

energy development. These impacts were quantified in terms of jobs, earnings, and additional economic output.

Using the NREL JEDI model, this study also quantified the additional economic impacts that would result from increased use of an in-state supply chain for components in solar energy development. The availability of these components is increasing as renewable energy manufacturers locate new facilities in the state.

Analysis of impacts on the transportation sector and quantification of the impacts of changes in energy prices, beyond changed demand for energy types, are beyond the scope of this study. An increase in electricity or gasoline prices might have general equilibrium effects on Arizona's economy due to an increase in the cost of consumer goods or reduction in consumer spending. These impacts are extremely difficult to predict confidently, however, and analyses to date attempting to forecast quantitatively the increase in consumer electricity prices due to cap-and-trade legislation run a wide range and are considered to be speculative at best (Parker & Yacobucci 2009).

The impact of implementing a nationwide climate change mitigation program, such as carbon pricing, has been measured by multiple parties in comparison to a 'business-as-usual' reference scenario in which economic prosperity and abundant cheap energy appear to continue, guaranteed, into the indefinite future. Such a reference scenario, however, does not take into account the impact of *not* attempting to mitigate climate change; that is, the true reference scenario against which the impacts of carbon pricing are measured should include the economic impacts on the state of dealing with a rapidly warming Southwest with less predictable yet more extreme weather patterns. An overview of this reference scenario is presented in the following section.

Reference Scenario: Arizona's Future and Climate Change

Arizona's economy will be directly impacted by the effects of unmitigated climate change. Over the last decade, the state has been one of the fastest-growing in the nation. Additionally, Arizona is an electric energy exporter. That is, the state generates more electricity each year than Arizona customers require. Much of this electric generation is from combustion of fossil fuels i.e. coal and natural gas. Arizona also, however, lies in the area of the continental United States that will be impacted soonest, most directly, and most extremely by climate change. Nineteen out of 20 climate models predict that the American Southwest will experience a rapid transition to a more arid climate if climate change is left unchecked (Seager et al. 2007). Figure 1 shows the trend in precipitation minus evaporation predicted by these models.

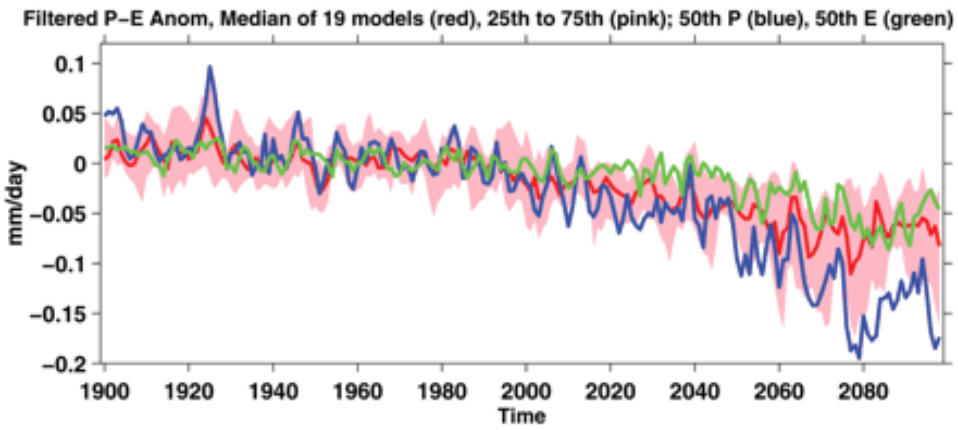

Figure 1. Precipitation minus evaporation. Source: Seager et al. 2007.

Predicted impacts on Arizona include:

- decreased precipitation and increased evaporation,
- increase in areas affected by drought and wildfire,
- increased incidence of warm-climate pests;
- longer heat waves and fewer cold nights.

In addition, the Intergovernmental Panel on Climate Change (IPCC) reports point out that the climate sensitivity of Arizona's indigenous, more natural-resource dependent communities, is higher than that of people in urban areas (IPCC 2007). This is also true for the natural-resource dependent agriculture and forestry sectors. Figure 2 shows the multi-model predicted change in precipitation over the next century for the periods December-January-February (left) and June-July-August (right). The American Southwest stands to see a reduction in precipitation of 10-20%.

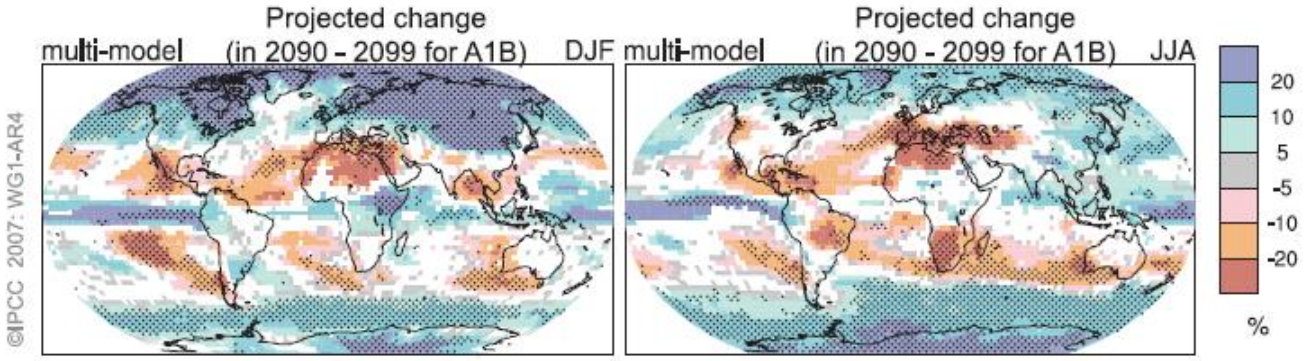

Figure 2. Projected (from 1980-1999 to 2090-2099) changes in precipitation. Source: IPCC 2007.

The physical effects of climate change will impact agriculture, industry, businesses large and small, and households. Decreased precipitation and increased evaporation in the region will lead to more frequent and longer droughts, simultaneously increasing the cost of, and demand for, water resources. Arizona currently uses more water in irrigation per acre than any other state in the country, and the impacts of climate change will only increase the need (and cost) for irrigation in agriculture. An increase in pests will

require new crop management practices and is already having disastrous impacts on the region's forests, leading to wildfires that are longer, larger, more costly to fight, and have a more catastrophic effect on forest health. Hotter days and longer heat waves will increase cooling costs for industry, business and homeowners.

A National Climate Change Mitigation Strategy

Proposals to mitigate the impact of climate change center around different strategies to reduce the emissions of greenhouse gases (GHG) including carbon dioxide. Multiple studies have predicted the impacts of a nationwide GHG mitigation program on the nation's economy and on the household welfare of families at a nationwide, regional, and state level. The results of these studies vary widely in their forecasts of energy costs, carbon prices, future electricity generation mix, and impacts on household welfare. When considering these studies collectively, however, it is clear that the costs of climate legislation will depend in large part on the nation's response to the technological challenges entailed in reducing emissions from electricity generation and selected industries.

Much of the economic modeling of the impacts of carbon pricing strategies on the economy shows negative net impacts on households. This is intuitive, because these models are introducing new costs and are comparing a system with these costs to a system without these costs. In general these models do not forecast the economic impacts of *not* imposing a carbon price; that is, the models do not describe the negative impacts on the nation's economy of the physical effects of climate change. In addition, these models do not include the potential economic growth that will result from a new economic focus on low-carbon or no-carbon technologies. Those studies that do include the economic development potential involved in shifting to a low-carbon economy show slight positive effects for the introduction of carbon pricing schemes.

The rationale behind the implementation of a nationwide climate change mitigation strategy is that it should yield GHG emissions reductions more effectively, and with less harm to local economies, than a piecemeal conglomeration of regional and state climate strategies would. Nevertheless, a price on carbon, however implemented, no matter how efficiently managed, will have an effect on carbon-emitting products and processes, such as electricity production and many industrial sectors. These effects will impact household welfare and will ultimately create a shift toward lower-carbon raw materials. This is not, however, an entirely negative effect. This transition creates new opportunities for the United States' labor force and manufacturing sector. An assessment of these opportunities is the focus of this research.

QUESTION:
Would the implementation of a national clean energy development and climate change mitigation program create significant economic benefits for Arizona?

ANSWER:
While the implementation of a nationwide GHG reduction strategy will certainly increase the cost of fossil-based energy and energy-intensive products, such a program also will create a larger market for Arizona's renewable resources and renewable energy R&D and manufacturing potential, due to increased demand

and competition for these resources nationwide. In addition, a nationwide climate change mitigation program will be a much less costly alternative to a) the impacts of unmitigated climate change on Arizona's economy[1] or b) the impacts on Arizona's economy of piecemeal regional and state climate change mitigation strategies[2].

In order to predict the impacts of changing demand for the state's various electricity generation types on Arizona jobs, assumptions must be made regarding those specific changes that result from the implementation of a nationwide climate change mitigation program. Nationwide changes in demand for quantities and types of electricity generation due to climate legislation can be and have been projected by several studies (CRS 2009; Paltsev et al. 2007, 2009). In addition, changes in utility decision-making in response to climate legislation have been modeled at the utility and regional level (EPRI 2008; ASU 2009). These projections can be used to make informed assumptions about the trends in Arizona's electricity generation sector, based on the nationwide shifts, and their potential impact on Arizona's electricity generating future.

Dozens of reports quantify the job creation impacts or potential of the renewable energy and energy efficiency sectors (Werner 2008). According to a report released by the American Solar Energy Society, the renewable energy and energy efficiency industries created 8.5 million jobs in 2006 (Bezdek 2007). The U.S. Conference of Mayors quantified current and potential green jobs in the U.S., estimating that 4.2 million new green jobs could be generated over the next two decades (USCOM 2008). These numbers are significant, given that the total employment in the United States is around 130 million (Bureau of Labor Statistics, 2010). *Finally, several studies quantifying the jobs related to renewable electricity generation and energy efficiency capacity have shown that these types of development generate more jobs than other energy-related industry sectors, and that an aggressive national energy efficiency and renewable energy standard could generate more than 4 million job-years by 2030 (Wei et al. 2010).*

Arizona's Current Electricity Generation Mix

Arizona's population grew 29% from 2000 to 2008, and is projected to grow to 12.8 million in 2050 (Arizona Department of Commerce, 2009). As the state's population has increased, so too has the electricity usage per household (Arizona Department of Commerce, 2009). Despite Arizona's rapid population growth and increased per-capita energy consumption, Arizona is a net exporter of electricity, generating nearly 33% more electricity than is used in the state (EIA State Electricity Profile for Arizona, 2010). The greatest proportion of this generation comes from coal-fired power plants. The historical electricity generation mix is shown in Figure 3.

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[1] Inaction or insufficient action to address climate change has been predicted to be significantly more costly than mitigation measures (Stern 2006).

[2] A 2009 interagency report, published by the U.S. Environmental Protection Agency, on the impact of comprehensive carbon pricing schemes on the international competitiveness of energy-intensive U.S. industry sectors, pointed out that emissions restrictions on the part of one nation could lead these industries to move to regions with lesser protections, resulting in "emissions leakage" due to unequal regulation of emissions across borders. The most effective approach for addressing these concerns, according to the report, "is to ensure significant action by all major emitters through ongoing international negotiations" (EPA 2009). The same logic can be applied to regional regulatory schemes inside the United States.

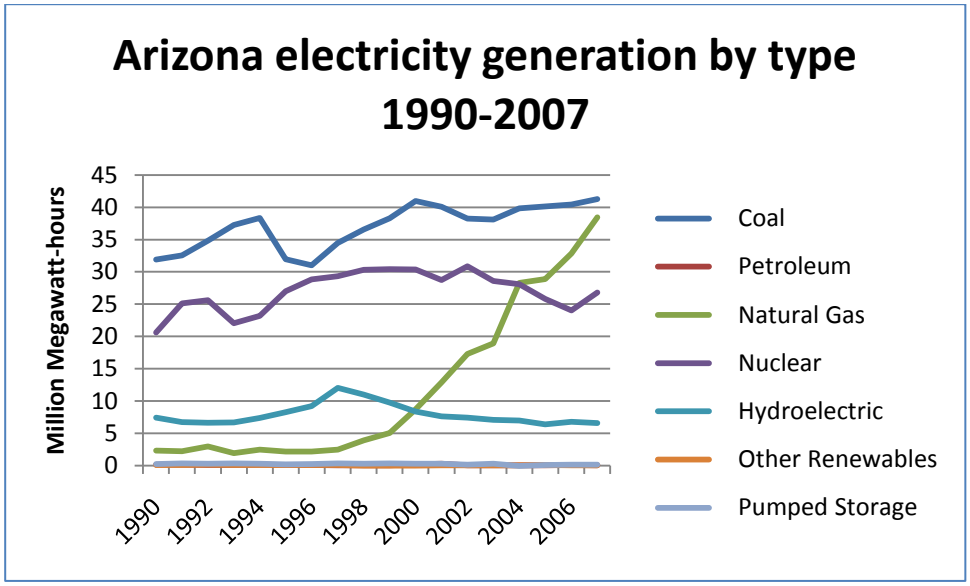

Figure 3. Arizona's historical electricity generation. Source: Energy Information Administration 2009.

Total electricity generation in the state grew from 62.8 million MWh in 1990 to 113.3 million MWh in 2007. Retail sales of electricity to Arizona customers in 2007 were 77.2 million MWh. The total carbon dioxide emissions associated with Arizona's historical electricity generation are shown in Figure 4.

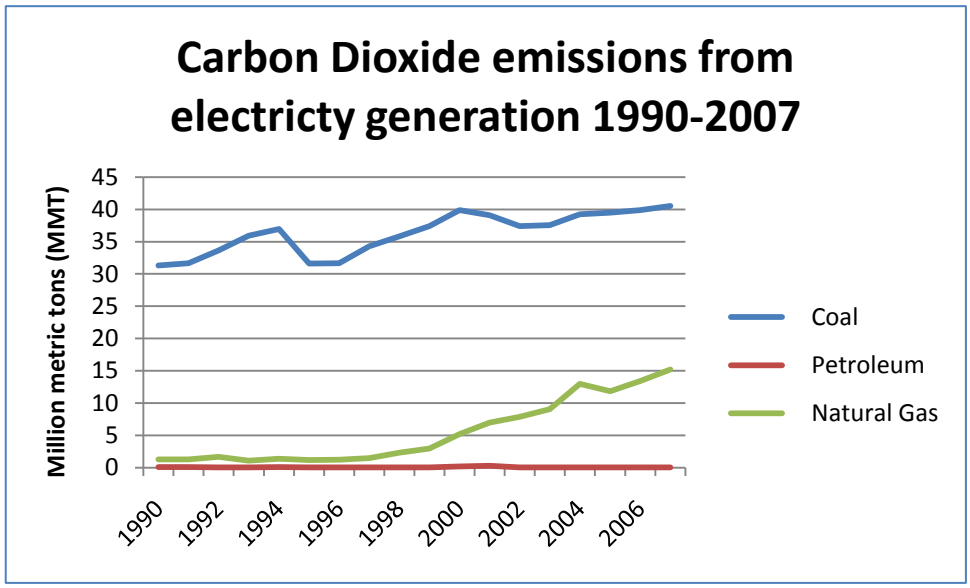

Figure 4. CO_2 emissions from Arizona electricity generation. Source: Energy Information Administration 2009.

Clearly, Arizona utilities need to continue to meet consumer demand, and will need to plan resource expansion to do so in a manner that takes into account potential future climate and energy legislation. Figure 5 shows existing electricity generating stations in Arizona, as well as the state's renewable energy development potential.

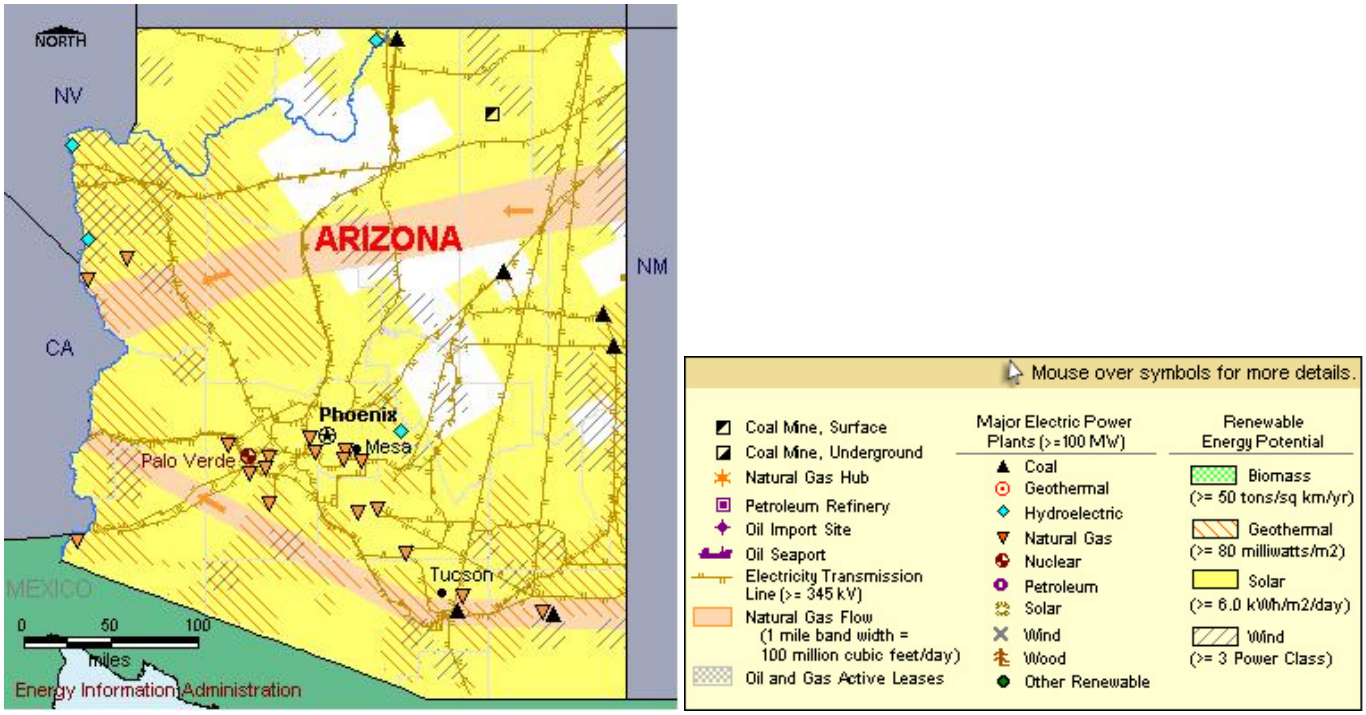

Figure 5. Electricity sources and energy development potential in Arizona. Source: EIA 2009.

Arizona Utilities' Resource Plans

Arizona utilities engage in resource planning as a fiscal management and regulatory compliance activity. Utility infrastructure can take a long time to build (up to decades, in the case of nuclear power plants), and has a long planned useful life. Thus decisions made today about infrastructure choices will affect the resource mix for more than 50 years. Figures 6 and 7 show projections from Arizona Public Service Company (APS Resource Plan 2009) and the Salt River Project (Salt River Project Annual Sustainability Report 2009). These plans demonstrate the forward-looking nature of the resource planning process, and show each organization's plan for increasing development of clean energy sources.

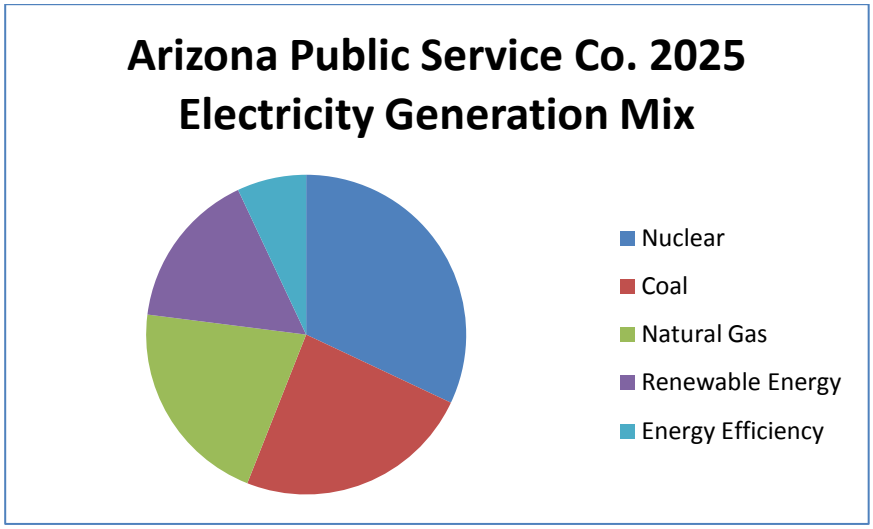

Figure 6. APS' expected electricity generation resource mix in 2025. Data Source: APS Resource Plan, 2009.

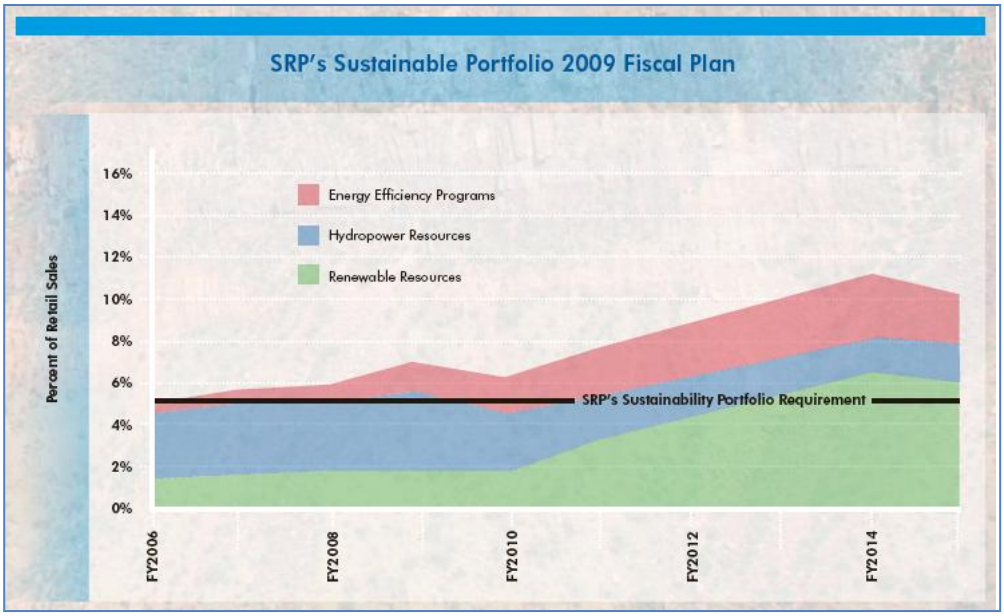

Figure 7. SRP's expected use of energy efficiency, hydropower, and other renewable resources. Source: SRP 2009 Sustainability Portfolio.

Arizona Utilities' Current Employment

Current direct employment statewide in the utilities sector totals 12,500. Arizona Public Service Company employs approximately 4000 people: roughly 3000 in nuclear generation, nearly 900 in coal-fired generation, approximately 175 in natural gas generation, and another 100 in engineering and operations support (personal communication, Debra Orr, January 2010). Tucson Electric Power employs 363 people at its coal-fired plants and 3 at its natural-gas-fired plants (personal communication, Phil Dion, January 2010). The Salt River Project employs 215 people at its natural-gas-fired plants, and 798 at its coal-fired plants (personal communication, Kelly Barr, February 2010).

Assumptions on Changes in Demand for Energy Sources

No matter how a climate mitigation strategy is implemented, it will impact demand for energy sources. That is, in its essence, the point of such a program. The precise impact is difficult to gauge, both because it is highly dependent on program implementation choices and because it is dependent on technology development that is difficult to predict. General assumptions and statements can be made, however, about likely changes in Arizona's electricity sector.

Understanding Impacts on Electricity Generation

An Electric Power Research Institute study (2009) modeled the impacts on utilities of various carbon pricing schemes. The impact on utility decision-making was the focus of the study, which highlighted the difficult choices that utilities have to make about near-term and long-term planning in the absence of exact information about future carbon costs and technology development. The following section illustrates the basic immediate decision-making process that is impacted by carbon pricing; naturally, long-term planning for capacity expansions and upgrades is based on a variety of carefully calculated assumptions and is also dependent on carbon price levels and rates of technology advancement.

Fuel vs. Carbon Prices

Different carbon dioxide emissions permit prices have different impacts on the demand for different types of electricity generation, due to the relative carbon intensities of their fuels. The fuel price and carbon price can combine to create "tipping points" at which one type of electricity generation becomes more economically viable than another due to an increase in carbon price. For example, using the average 2007 fuel prices, emissions rates, and electricity generation rates for coal and natural gas in Arizona (Energy Information Administration State Electric Profiles, 2009), it can be seen that while coal is far less expensive than natural gas as an electricity generating fuel source, natural gas would become a less expensive option at a carbon dioxide price of $30/ton. This calculation, shown in Table 1, ignores any difference in operating costs or other considerations and factors in electricity pricing; it is meant merely to illustrate that carbon pricing alone could change the economic viability of a particular fuel choice.

Table 1. Fuel cost vs. Carbon cost 'tipping points.' Data source: EIA 2009.

Fuel Source	$/MMBTU	Fuel costs per MWh	CO_2 per MWh in metric tons	Carbon cost/MWh with CO_2 at $30/ton	Net $/MWh
Coal	$1.59	$5.43	0.982	$29.47	$34.90
Natural Gas	$10.22	$22.87	0.395	$11.85	$34.71

Sources: Fuel costs, generation rates, and emission rates from Energy Information Administration State Electricity Profiles data tables 2009; conversion rate of 3414 BTU/KWh. Arizona residential retail electricity prices in 2009 averaged $107.40/MWh.

Expanded Clean Energy Development Scenarios

This section describes the impacts of a low-carbon electricity generation development scenario for Arizona, quantifying the impacts on the state in terms of annual jobs, earnings, and other economic output, for

direct, indirect and induced impacts. All of the tables were produced using the NREL Jobs and Economic Development Impacts (JEDI) model except for those related to nuclear power development[3]. Earnings refer to the wages paid to those holding the listed jobs. Output refers to additional economic activity such as the hiring of accounting services to support the operation of a plant. Direct impacts take place on site in a plant. Indirect impacts refer to supply chain impacts and the hire of secondary, offsite service providers such as electricians. Induced impacts refer to changes in the local economy that result from the changes in household income of those affected by the direct and indirect impacts. Examples include changes in spending at retail stores, restaurants, entertainment establishments, and childcare facilities. Construction-phase jobs are assumed to last about a year. The impacts of renewable energy developments do not include any information about tax revenue or its impacts, since assumptions regarding the use of tax incentives or level of taxes for different types of energy development projects on tribal or other lands can vary widely. In addition, these impacts assume that local products and services are used when available.

In terms of the location of developments for each of these energy sources around the state, natural gas power development could take place anywhere in Arizona near available or new electricity transmission. Wind power development is likely to take place in rural areas in the northern and eastern regions of the state where the wind resource is the strongest. Solar power development could take place in any of the rural areas of the state, as the resource is outstanding, and the electricity generated can be used locally or can feed the state's urban electricity load centers. Nuclear power development will take place in western Maricopa County at the site of the existing Palo Verde Nuclear Power Plant. Geothermal resources are shown in Figure 5, and Biomass plants could be located in several of the wooded areas of the state.

Coal

As described previously, coal – fired electric generating units (EGUs) are the largest component of Arizona's current generation mix. These large facilities range in age from very new (Springerville) to units that have exceeded their expected useful life. Operators of Arizona's EGUs anticipate, however, that these facilities will continue operation for an additional decade or longer. These plans are logical given amortized capital investments, relatively low fuel and operating costs, and tailored infrastructure. Further, large consumers of electricity from Arizona's coal-fired EGUs have become reliant on this relatively inexpensive power source.

Research by the electric utility industry (EPRI et al.) suggests existing coal-fired EGUs will continue operation until such time as the "price of carbon" causes costs to be non-competitive. Considering current proposals for national climate policies and the associated price of carbon, Arizona's existing coal-fired facilities will generate cost-competitive electricity for another decade or more. The cost of electricity to Arizona consumers (and consumers of Arizona's exported electricity) will rise as a function of carbon price, natural gas and coal prices, penetration of renewable energy generation in the market, age of equipment, and other factors. Therefore, no national climate policy currently under consideration is expected to

[3] The nuclear power development impacts were generated by converting the impact figures from *The Economic Benefits of Palo Verde Generating Station, Nuclear Energy Institute 2004* to 2010 dollars using the discount rate in the JEDI model.

impact employment, tax revenues or associated economic benefits from Arizona's existing fleet of coal-fired EGUs until 2020 and, most likely, well beyond.

Nuclear Power

Palo Verde nuclear power generating station currently operates three 1.27 Gigawatt reactors. The plant owners have had permits in place since the 1970s to construct two additional reactors, but have not, in the intervening four decades, found it cost-effective or necessary to initiate this construction. Impending climate legislation, however, has created new impetus for nuclear power development. Arizona Public Service Company plans to develop at least one of these reactors by 2023 (APS Resource Plan 2009), and the other will likely be developed in reaction to the increased demand for carbon-neutral electricity generation. Based on current employment and economic impact statistics from a 2004 Nuclear Energy Institute report, these additions (of two new reactors) will generate the annual jobs, earnings and outputs shown in Table 2. These additions would not likely be made in the absence of carbon pricing, due to the expense of nuclear power development and the lack of permanent waste repository facilities. Construction-phase impacts are not included.

Table 2. Impacts of developing two additional nuclear power generation towers at Palo Verde power plant.

Nuclear Plant annual impacts			
Size	**2.88 GW**		
Direct Jobs	**1590**	Indirect Jobs	**1050**
Direct Earnings & Output	**$338 M**	Indirect Earnings & Output	**$163 M**

Natural Gas

Increased investment in renewable energy will require the development of some additional natural gas capacity to accommodate the variability of these resources. The statewide annual economic impacts of operating 2500 MW of natural gas capacity are shown in the following table. Several developments of this magnitude might take place around the state. The total direct, indirect, and induced *construction phase impacts* of developing this quantity of natural gas capacity would create more than 5200 construction-phase jobs, and would generate more than $250 million in earnings and $700 million in additional economic activity.

Table 3. Impacts of developing 500 MW of natural gas capacity in Arizona. Source: NREL JEDI model data.

Natural Gas Plant annual impacts			
Size	**2.5 GW**		
Direct Jobs	**125**	Indirect and Induced Jobs	**280**
Direct Earnings & Output	**$19 M**	Indirect and Induced Earnings & Output	**$58 M**

Concentrating Solar Power

While some large solar photovoltaic installations are planned for Arizona or are under discussion by regional utilities for development in the state or its neighbors, much larger quantities of concentrating solar power (CSP) are likely to be developed, due to the technology's relative affordability, particularly as low-water-use CSP varieties, such as the Stirling Energy Systems power towers, mature technologically. The following table shows the statewide annual economic impacts of operating 2500 MW of CSP Trough capacity. These numbers include the supply chain impacts based on the availability of components in the state in 2008, and do not reflect the increased impacts that would result from the new CSP businesses that are locating in Arizona. The total direct, indirect, and induced *construction phase impacts* of developing this quantity of CSP Trough capacity would create more than 36,000 construction-phase jobs, and would generate $2.6 billion in earnings and $5.6 billion in additional economic activity.

Table 4. Impacts of developing 2500 MW of CSP capacity in Arizona. Source: NREL JEDI model data.

	CSP Trough Plant annual impacts		
Size	**2.5 GW**		
Direct Jobs	**240**	Indirect and Induced Jobs	**340**
Direct Earnings & Output	**$44 M**	Indirect and Induced Earnings & Output	**$67 M**

These construction and operation phase employment figures will be dramatically impacted by the increasing availability in Arizona of solar energy conversion components and other items in the supply chain. The JEDI model calculates the impact of an investment in solar capacity construction as a function of the local spending on goods and services. Thus, if this goods and services availability is increased in the model, the impact increases. Figure 8 shows the current *construction-phase* employment for 500 MW of CSP development, and the employment that would result if the following components were purchased exclusively from manufacturers in Arizona: mirrors, heat collection elements, thermal energy storage tanks, heat exchangers, heat transfer system equipment, and other solar and electrical equipment. It is important to note that the increased supply chain employment leads to increased employment in other, unrelated sectors of the state's economy.

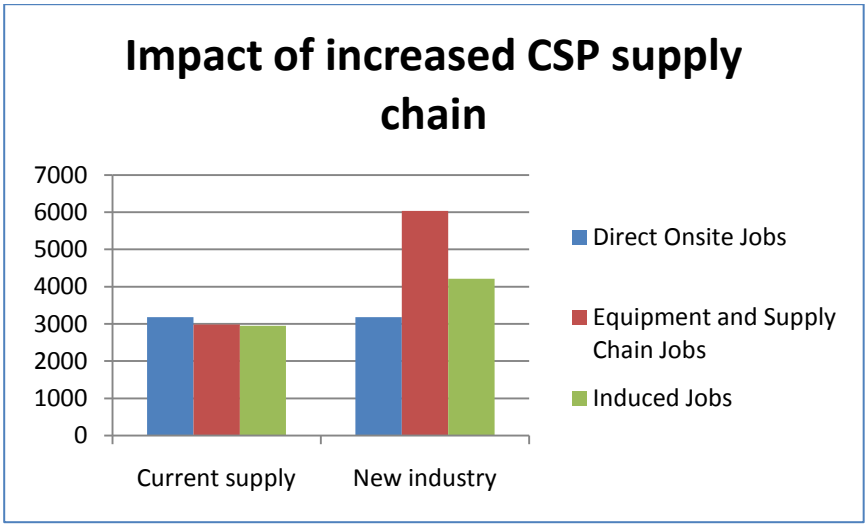

Figure 8. Increased construction-phase job creation due to increase in Arizona CSP manufacturing.

Wind Energy Development

Wind energy development has begun in Arizona, and several thousand MW of development are under discussion by developers across the state (Wadsack 2009). These and other in-state wind developments are likely to become much more economically viable if a national clean energy program is established. The statewide annual economic impacts of 2500 MW of wind development are shown in the table below. These numbers include the supply chain impacts based on the availability of components in the state in 2008, and do not reflect any increased impacts that might result from the new wind component businesses locating in Arizona. The total direct, indirect, and induced *construction phase impacts* of developing this quantity of wind capacity would create more than 11,500 construction-phase jobs, and would generate $525 million in earnings and $1.5 billion in additional economic activity.

Table 5. Impacts of developing 3000 MW of wind capacity in Arizona. Source: NREL JEDI model data.

	Wind Plant annual impacts		
Size	**2.5 GW**		
Direct Jobs	**115**	Indirect and Induced Jobs	**260**
Direct Earnings & Output	**$18 M**	Indirect and Induced Earnings & Output	**$47 M**

Case studies: renewable energy, energy efficiency, and green building products and services in Arizona

An Arizona State University/ Arizona Investment Council study on the impacts of carbon pricing on Arizona (2009) suggested that the limited facilities and renewable energy producers in the state would result in most of the economic benefits for renewables flowing out of state. In addition, a lack of businesses in the energy efficiency or green building industries would mean that the state's economy couldn't take advantage of a shift toward the use of these industries' products and services. These industries are booming in Arizona, however, and are likely to continue to develop and succeed, not only during the period of accelerated federal "stimulus" funding, but beyond that period as a culture of energy conservation develops in the state and as state residents experience firsthand the increased costs of climate change. As

shown by the JEDI model results in Figure 8, an increase in clean energy and technology development and manufacturing in the state can have a dramatic positive effect on the impacts of investment in renewable energy development. That is true no matter where the development takes place, if the manufacturing takes place in Arizona.

Because Arizona is a state of extreme temperatures and extreme aridity, its residences, businesses, and government buildings have an opportunity to gain greater advantage from building efficiency and conservation measures than those in more temperate regions of the country. These measures are the focus of much of Arizona's State Energy Program's $55.4 million American Recovery and Reinvestment Act (ARRA) program spending.

Arizona has seen a recent increase in the development of small businesses and the establishment of manufacturing facilities and corporate headquarters for renewable energy, energy efficiency, and green building products and service. Some of this is in response to the federal government's recent prioritization of these types of businesses, but a large part of it is an entrepreneurial reaction to impending climate legislation.

The Arizona Department of Commerce has been tracking the businesses that fall into the "solar supply chain" or "green tech" categories. Tables 6 and 7 show the type and quantity of these businesses in each county in Arizona. In addition, the Department of Commerce's Council on Commerce and Economic Research is in the initial phases of performing a labor market survey to identify and track all types of "green jobs" in Arizona.

Table 6. Source: Arizona Department of Commerce, June 2009.

County	Solar Component Manufacturers	Solar Wholesaler, Retailer, Installer	Other, Solar Related	Solar Research Org. / Facility	Wind Manufacturing
Apache					
Cochise					
Coconino		4			1
Gila					
Graham	1		1		
Greenlee					
La Paz					
Maricopa	27	25	5	4	1
Mohave	1				
Navajo		1			
Pima	12	9			
Pinal		1		1	
Santa Cruz					
Yavapai	1	3			
Yuma		1			

Table 7. Source: Arizona Department of Commerce, June 2009.

County	Water Conservation & Building Efficiency	Wood Fiber and Biomass Products	Renewable Energy R&D	Daylighting & Green Manufacturing	Environmental Products and Process Efficiency
Apache					
Cochise					
Coconino			1		
Gila					
Graham					
Greenlee					
La Paz					
Maricopa	20	2	7	5	6
Mohave					
Navajo		1			
Pima					
Pinal	3	1		2	1
Santa Cruz					
Yavapai	1				
Yuma					

State Energy Office 'stimulus funding' programs

ARRA allocated $55.4 million in funding to Arizona's State Energy Office to expand its program offerings. The details of these programs, including anticipated job creation, are shown in Table 8. This funded shift toward a lower-carbon economy provides an extraordinary opportunity for Arizona to take advantage of the changes in demand for different energy sources, and energy efficiency products and services, which would be augmented by national climate change or clean energy legislation. These programs help to establish a trained workforce in low-carbon energy technologies, and they leverage existing funds to increase demand for these projects. In addition to these programs, $5 Million in ARRA funding was allocated to the state from the United States Department of Labor for the purpose of training more than 1500 Arizona workers in the fields of energy efficiency and renewable energy.

Table 8. Expanded funding for State Energy Program. Source: State Energy Office 2010.

State Energy Program Stimulus Funding Expansions

Program Title	Funding	Details	Expected Leveraged Job Creation
Energy Efficiency & Renewable Energy in Schools	$20 Million	School Facilities Board allocated 70% to energy efficiency and 30% to solar	826
State Building Energy Performance Contracting	$10 Million	Department of Administration will implement efficiency and renewable projects on state facilities	543
21st Century Energy Grant	$11.9 Million	Funds studies to develop renewable energy sources and projects	136
Distributed Energy Leadership	$10 Million	Funding used to increase or match utility incentives for distributed renewable energy projects	Unknown as yet
Revolving Energy Loan	$2 Million	Funding for projects on commercial buildings including renewable and energy efficiency component manufacturers	22
Agricultural Renewable Energy Conversion Incentive	$1.5 Million	Funding to convert fossil-fueled agricultural facilities to renewables	33

Solar Roadmap

The Arizona DOC's Commerce and Economic Development Commission identified solar in 2004 as an "economy defining" industry opportunity for AZ (Navigant 2007). In a 2007 report for the Arizona DOC, Navigant Consulting identified a framework of policies for the state to accelerate the development, manufacturing, and deployment of solar technologies in the state.

The report identified policy strengths and barriers to accelerated deployment of solar electricity generation in Arizona. Policy responses in the state to Arizona's current economic conditions and the prospect of carbon pricing could certainly accelerate the removal of many of these barriers, such as cost-prohibitiveness, local or state anti-solar policies, competition from other states and countries, and lack of an educated installation and maintenance workforce. In fact, several of the ARRA-funded projects shown in the previous section specifically address these barriers.

If accelerated deployment takes place, the report suggested that solar power installations could reach more than 2500 MW of capacity by 2025. This would result in the creation of manufacturing, installation

and maintenance jobs, and naturally would contribute to reductions in GHGs from electricity generation in the state. These cases and the resulting job creation and GHG reduction are shown in Figures 9, 10 and 11.

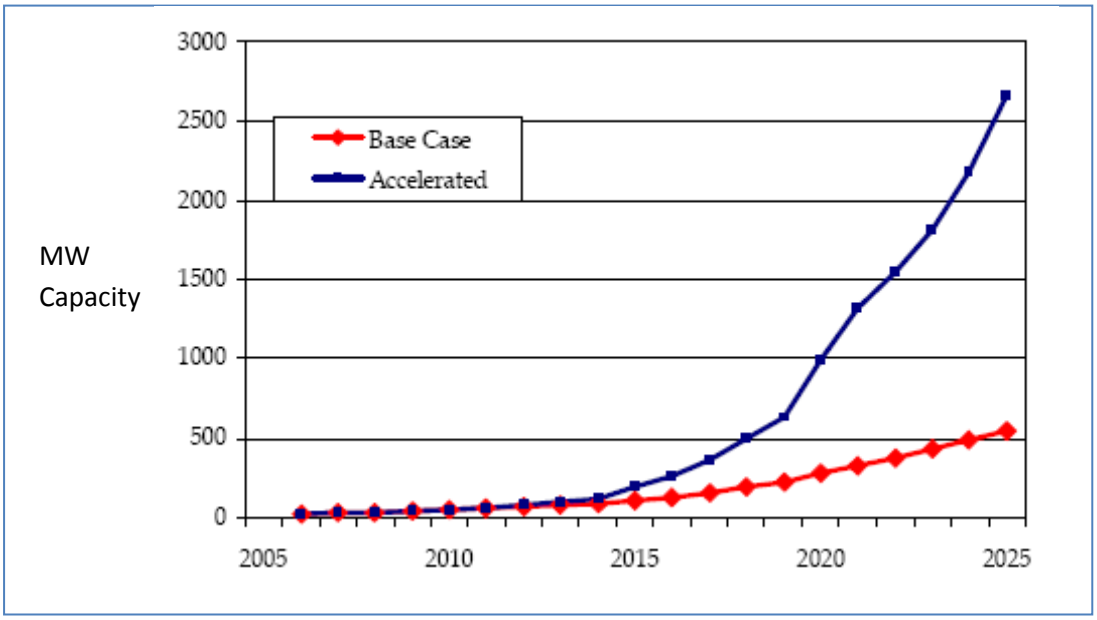

Figure 9. Increased development of solar energy sources in Arizona (in MW capacity) under accelerated deployment scenario. Source: Arizona Department of Commerce Solar Roadmap 2007

Accelerated Scenario In 2020	Cumulative Capacity (MW)	Installations in 2020 (MW/yr)	Direct Manufact. (# Jobs*)	Installation/ Construction (# Jobs)	O&M (# Jobs)	Installation Labor Expenditure (Million $)	O&M Labor Expenditure (Million $)
Rooftop PV	250	115	450	1,800	75	243	4
Central Solar	742	143	60	429	233	54	26
TOTAL	992	258	510	2,229	308	297	30

*Assumes none of central solar components are manufactured in AZ, except for PV where 20 MW were assumed to be manufactured in state. Assumes that an additional 150 MW plant is in AZ for the rooftop PV market (some in state and some exported).

Source: Navigant Consulting, Inc. estimates, June 2006.

Figure 10. Increased jobs and expenditures in 2020 under accelerated solar power development scenario. Source: Arizona Department of Commerce Solar Roadmap 2007

Accelerated Scenario	Cumulative Capacity (MW)	Average Capacity Factor (%)	Energy Delivered (MWh)	Total CO_2 Reduction (Tons)
Rooftop PV	250		388,075	60,000
• Residential	187	18.3%	299,775	
• Commercial	63	16%	88,300	
Central Solar**	742		2,182,500	338,200
• Trough	519	38%	1,728,000	267,800
• Dish Stirling	148	23%	299,000	46,300
• PV	37	25%	81,000	12,600
• Concentrating PV	37	23%	74,500	11,500
TOTAL	992	26.3%	2,570,575	398,200

*Assumes .31 lbs/kWh of CO2 are displaced for a Combined Cycle Gas Turbine in 2020.
** Assuming market shares of: 70% trough, 20% dish Stirling, 5% concentrating PV, and 5% flat plate PV based on economics.

Source: Navigant Consulting, Inc. estimates, August 2006.

Figure 11. Installed solar capacity and resulting GHG emissions reductions under accelerated solar development scenario. Source: Arizona Department of Commerce, Solar Roadmap 2007

State Policy Incentives for Renewable Energy and Energy Efficiency Development

Arizona, like many states, has a Renewable Energy Standard and Tariff, and the Arizona Corporation Commission recently implemented an Energy Efficiency Standard to complement it. These regulatory programs create additional demand for renewable and energy efficiency development, but do not explicitly provide incentives to encourage that development. Several incentive programs do exist, and others are under consideration by the Arizona legislature. These programs help to remove the barriers to rapid renewable energy and energy efficiency deployment in the state.

Arizona Senate Bill 1403, signed into law in 2009, established state corporate income and property tax credits for renewable energy manufacturing facilities locating in Arizona, which pay above-average wages and provide above-average benefits to their employees. Arizona House Bill 2241, under consideration by the Arizona State Legislature in 2010, would provide state income tax incentives to utility-scale renewable energy production facilities based on their energy production. Both of these financial incentives increase demand for renewable energy project development in the state that should lead directly to increased revenue and job growth.

Green Business Stories

Renewable energy manufacturing companies with facilities in Arizona include Stirling Energy Systems, Southwest Windpower, FirstSolar, and Kyocera Solar, Inc. Several other companies have recently announced plans to establish manufacturing or service facilities in the state. In addition, the Navajo Green

Economy Commission and Fund were recently passed by the Navajo Nation Council, establishing a mechanism for the Nation to invest in sustainable, healthy employment opportunities for its residents.

Stirling Energy Systems is a manufacturer of concentrating solar power dish-type solar energy capturing devices, which are in use in installations worldwide. The company expanded its global headquarters in Scottsdale, Arizona in May 2009, with 90 employees, and expected to have a total of 140 employees by the end of 2009. Tower Automotive, one of the company's component providers and a Michigan business that also manufactures automotive parts, recently announced plans to open a manufacturing facility in Arizona to supplement production of the mirror troughs used in the solar energy devices.

The SunCatcher unit produced by Stirling is being installed in Peoria, Arizona at a 1.5 MW solar energy facility. Tessera Solar, the exclusive developer of solar energy projects using this technology, has contracts in place to construct 1,500 MW of solar energy capacity across Arizona, Texas and California. The Phoenix City Council recently approved a 150-200 MW solar power plant development at a city landfill in Buckeye. Tessera Solar will invest roughly $1 Billion in the plant, which is expected to create 300 construction-phase jobs (O'Grady 2010).

Southwest Windpower, the nation's leading manufacturer of small wind turbines, has its corporate and manufacturing facilities located in Flagstaff, Arizona. The company employs about 85 people and may be expanding in the near future (Ferguson 2010).

FirstSolar, the world's largest thin-film solar panel manufacturer, is headquartered in Tempe, Arizona. In 2009, FirstSolar became the first PV panel manufacturer in the world to build and ship more than a gigawatt of panel capacity in one year. The company's rapid growth worldwide has led to an expansion in its corporate headquarters; employment grew from roughly 90 people in the beginning of 2009 to about 130 people at the beginning of 2010 (personal communication, Melanie Freedman, February 2010).

In addition to these companies, several others recently received federal tax credits as incentives for building manufacturing and service facilities in Arizona, as shown in Table 9. The establishment of these facilities in Arizona will provide immediate employment, but it will also take advantage of the growing solar energy industry, allowing investments in solar energy development projects, within the state and around the country, to generate indirect and induced economic impacts on Arizona's economy.

Table 9. New solar component facilities to locate in Arizona.

Company	Facility Type	Job Creation
Standard Renewable Energy	Renewables and efficiency Installation	50 within a year
Suntech	Solar panel manufacturing	75, expanding to 250
Yingli Green Energy Holding Co.	Solar panel manufacturing	Unknown
Saint-Gobain	Solar mirror manufacturing	Unknown
Amonix, Inc.	Solar-power system factory	Unknown
Rioglass Solar Inc.	Solar manufacturing	Unknown

In Summer 2009, The Navajo Nation Council passed the Navajo Nation Green Economy Commission Act of 2009 and the Navajo Nation Green Economy Fund Act of 2009. This legislation provides a mechanism for the Navajo Nation to fund and guide investments in green jobs and economic development on the Nation. The focus will be on small-scale projects for economic development to empower local communities. The Commissioners will seek federal, state and other funding for the program, and will work with local, state, national and international groups, as well as coordinating with existing Navajo nation divisions and agencies to develop Navajo Nation green economy strategies.

Conclusion and Recommendations: Arizona's Preparedness for Clean Energy Development

Arizona is well-positioned to benefit from the opportunities presented by a nationwide climate change mitigation and clean energy development program, and stands to suffer serious negative economic impacts if the effects of climate change are left unchecked. Quite simply, Arizona can stimulate economic and job growth much faster with these programs than without.

While several local and state policies encourage the development of renewable energy resources and the expansion of the renewable energy supply chain and R&D sector in the state, there are areas in which policy improvements could dramatically increase the feasibility and economic viability of these developments. These include:

- Supporting national climate change mitigation and clean energy legislation. *This would support the development of the clean energy and technology sectors in Arizona by increasing demand nationwide. It would also take a step toward reducing the potential future harmful impacts of climate change on Arizona's economy.*
- Streamlining permitting processes across agencies and jurisdictions in order to assist agency employees and developers in performing due diligence and issuing/obtaining permits in a fair and timely fashion. *This would facilitate the development process and provide agency and local government employees with consistent information and support for their regulatory processes.*
- Providing additional incentives to low-carbon energy developers or manufacturing companies, and establishing mechanisms to provide equivalent incentives to those provided elsewhere in the state for renewable energy development on tribal land or under tribal ownership. *This would attract additional investment in the renewable energy and clean technology sectors in Arizona, and remove some of the barriers to tribal development opportunities.*
- Establishing a state clean energy development agency (perhaps as a subsection of the existing State Energy Office) to coordinate with research institutes, industry, government agencies and developers. *This would streamline the Research, Development and Deployment process for new technology, and would help create an inviting environment for renewable energy and clean technology developers and investors.*

References

Arizona Department of Commerce (2010). Arizona Indicators Project. Available at: http://www.arizonaindicators.org/pages/global/population-basics.html

Arizona Department of Commerce (2010). Population and Demographics. Available at: http://www.azcommerce.com/EconInfo/Demographics/

Arizona Department of Commerce, State Energy Office, State Energy Programs information (2010). Available at: http://www.azcommerce.com/Energy/SEP.htm

Arizona Public Service Company website resources (2010). Available at: http://www.aps.com/general_info/AboutAPS_18.html, http://www.aps.com/main/various/ResourceAlt/default.html and http://www.aps.com/files/_files/renewable/renewmap.pdf

Arizona State University, W.P. Carey School of Business, L. William Seidman Research Institute (2009). An Assessment of the Economic Impacts on the State of Arizona of the Imposition of a GHG Emission Allowance Trading Program. Arizona Investment Council. Available at: http://www.arizonaic.org/images/stories/pdf/rpt_economicimpactofcarboncontrolsinarizona.pdf

Bezdek, R.H. (2007). *Economic and Jobs Impacts of the Renewable Energy and Energy Efficiency Industries: U.S. and Ohio.* American Solar Energy Society, July 2007. Available at: http://www.ases.org/images/stories/ASES-JobsReport-Final.pdf

Coates, J. (2009). Stirling Energy Systems Expands Global Headquarters in Greater Phoenix With Plans to Grow to 140 Employees By The End of 2009. Available at: http://www.stirlingenergy.com/pdf/2009-05-14.pdf

Economic Development Research Group Inc (2006). *Economic Impacts of the Proposed Northeast Regional Greenhouse Gas Initiative.* Prepared for the Staff Working Group of the Northeast Regional Greenhouse Gas Initiative. Boston, Massachusetts. Available at: http://www.edrg.info/pdf/rggi%20economic%20impacts%20report%20edrgroup%20-%20final042106.pdf

Electric Power Research Institute (2008). *Understanding the Impact of Climate Policy on Electric Company Compliance and Investment Decisions.* Report no. 1015635. Palo Alto, California.

Ferguson, J. (2009). *Wind Power Company Committed to Flagstaff*. Arizona Daily Sun, February 14, 2010.

Field, C.B., Mortsch, L.D., Brklacich, M., Forbes, D.L., Kovacs, P., Patz, J.A., Running, S.W., and Scott, M.J., (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Navigant Consulting, Inc. (2007). *Arizona Solar Electric Roadmap Study*. Prepared for the Arizona Department of Commerce. Available at: http://www.azcommerce.com/doclib/energy/az_solar_electric_roadmap_study_executive_summary.pdf

O'Grady, P. (2010). *Phoenix OKs $1B solar landfill deal for Tessera in Buckeye.* Phoenix Business Journal, February 17, 2010. Available at: http://phoenix.bizjournals.com/phoenix/stories/2010/02/15/daily49.html

Paltsev, S., Reilly, J.M., Jacoby, H.D.,Gurgel, A.C., Metcalf, G.E., Sokolov, A.P., and Holak, J.F. (2007). *Assessment of U.S. Cap-and-Trade Proposals.* MIT Joint Program on the Science and Policy of Global Change, Report No. 146. Cambridge, Massachusetts.

Paltsev, S., Reilly, J.M., Jacoby, H.D., and Morris, J.F. (2009). *The Cost of Climate Policy in the United States.* MIT Joint Program on the Science and Policy of Global Change, Report No. 173. Cambridge, Massachusetts.

Parker, L. and Yacobucci, B. (September 14, 2009). *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454.* Congressional Research Service, R40809. Washington. D.C.

Randazzo, R. and Beard, B. (2010). *Solar, Wind Tax Breaks to Aid Arizona.* The Arizona Republic, January 9, 2010. Available at: http://www.azcentral.com/business/articles/2010/01/09/20100109biz-energymoney0109.html

Rausch, S., Metcalf, G.E., Reilly, J.M., and Paltsev, S. (2009). *Distributional Impacts of a U.S. Greenhouse Gas Policy: A General Equilibrium Analysis of Carbon Pricing.* MIT Joint Program on the Science and Policy of Global Change, Report No. 182. Cambridge, Massachusetts.

Seager, R.,Ting,M., Held, I., Kushnir, Y., Lu, J., Vecchi, G., Huang, H-P., Harnik, N., Leetmaa, A., Lau, N-C., Li, C., Velez, J., and Naik, N., (2007) *Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America.* Science 25 May 2007: Vol. 316. no. 5828, pp. 1181 – 1184.

Stern, N., (2006). *Stern Review on the Economics of Climate Change.* Cambridge University Press. Cambridge, U.K.

United States Environmental Protection Agency (2009). *The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries: An Interagency Report Responding to a Request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown*. Washington, D.C. Available at: http://www.epa.gov/climatechange/economics/pdfs/InteragencyReport_Competitiveness&EmissionLeakage.pdf

Wadsack, K. (2009). *Arizona Wind Development Status Report.* Arizona Wind Working Group. Flagstaff, Arizona. Available at: http://www.landsward.nau.edu/windstatusreport.html

Wei, M., Patadia, S., Kammen, D.M., (2010). *Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the U.S.?* Energy Policy 38: 919-931.

Werner, C. (2008). *Jobs from Renewable Energy and Energy Efficiency Fact Sheet.* Environmental and Energy Study Institute. Washington, D.C. Available at: http://www.eesi.org/files/green_jobs_factsheet_102208.pdf

United States Bureau of Labor Statistics (2010). *Employment Situation Summary.* February 5, 2010. Available at: http://www.bls.gov/news.release/empsit.nr0.htm

United States Conference of Mayors (2008). *Current and Potential Green Jobs in the U.S. Economy*. Lexington, Massachusetts. Available at: http://www.usmayors.org/pressreleases/uploads/GreenJobsReport.pdf