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Renewable Energy Electricity Generation in Arizona: What, Why, and Maybe How

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SES SUSTAINABLE ENERGY SOLUTIONS

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However, fossil-fueled electric generation contributes to regional haze and other environmental problems, the public cost of which is not reflected in electricity prices. States have generally rejected mechanisms such as taxation that would raise the price of fossil-fueled generation to reflect the cost of environmental "externalities." The alternative is to adopt policies that offset the cost differential of renewable generation and ensure that an appropriate fraction of states' electrical supplies are generated from environmentally-preferable renewable resources.[1]

INTRODUCTION

The switch flips to ON, completing the circuit. Electrons go zipping by through miles of wire, powering the industrialized world, turning night into day and providing a standard of living unfathomable several generations before. Electricity is the principal force that powers modern society. It lights buildings and streets, runs computers and telephones, drives trains and subways, and operates all varieties of motors and machines. However, using current methods to produce electric power causes a growing array of problems threatening the very integrity of life as we know it.

For the last 100 years, Americans have used various methods to power appliances and gadgets that have been created since the Industrial Revolution. The era of large-scale electric power distribution arguably began on August 26, 1895, when water flowing over Niagara Falls was diverted through a pair of high-speed turbines coupled to two 5,000-horsepower generators.[2] Although changes would be made in the way power was generated, Niagara confirmed that large-scale generation and transmission of electricity was possible and practical. It set the stage for developments for the century to come.

Since then, monumental changes have occurred in the way that power is generated and distributed. Americans began using vast coal supplies to power steam turbines for their energy needs. The use of fossil fuels to power turbines continued to evolve, from coal to oil to gasoline and later, to natural gas. Soon after, with the advent of nuclear power, Americans were convinced that they had found a cheap, clean way to fulfill their electrical energy needs.

However, during the 1970's, several changes occurred in the way that people looked at power generation. During that decade, the nation underwent a serious power shortage that pulled the economy into the worst recession since the Great Depression. Later, the dangers of nuclear power generation introduced themselves in the form of a near-core meltdown at Three Mile Island in 1979. Disaster was averted, but people gradually grew more skeptical of nuclear power's claimed cleanliness and safety.

However, perhaps the greatest change occurred with a growing environmentally aware society who began recognizing that their day-to-day actions and activities had the power to change the entire world around them. People grew increasingly more aware of environmental problems associated with modern industrial living. As a result, the government and the general public began looking for cheap, clean and safe alternatives to non-renewable energy.

In 1970, with the people's overall support, the Clean Air Act was amended to improve the health standards in a variety of industries and clean up effluent from automobiles, factories and electrical power plants. These new regulations aimed to reduce sulfur dioxide, lead, carbon monoxide and unhealthy air particulates. Rigid command and control policies were put into place to enforce the new laws. Overall, these policies had wonderful results. A sizeable chunk of all the noxious waste was reduced drastically in less than 15 years. This was a remarkable effort considering industry and population were expanding at unprecedented rates.

Although command and control policies achieved tremendous success in accomplishing the stated goals of effluent reduction, they were terribly inefficient from an economic standpoint. Although effluent drastically decreased, cleaning up certain areas like St. Louis and the Delaware Valley in the late 1970's cost many multiples of what they perhaps should have.[3] Because of bureaucratic restrictions and the iron fist dictated by command and control policies, the desired results of the Clean Air Act were not executed as quickly, efficiently and effectively as could have been accomplished given different means.

In 1977, President Carter's administration revised Clean Air Act legislation with emphasis on making a difference in the way people generated and used electric energy. The revised legislation sought ways to power our nation's growing appetite for electricity, while finding environmentally benign ways to generate power. In addition, the Public Utilities Regulation Policy Act (PURPA) required all publicly owned electric utilities to buy power produced from private sources.[4] Despite its shortcomings, including requiring utility providers to pay "the wholesale avoided cost" rather than the full retail cost, PURPA legislation paved the way for later legislation that includes Arizona's net-metering policy. However, the revised amendments made little effort to revise the command and control policies set forth in 1970.

In 1990, President Bush's administration proposed legislation to revise some of the antiquated policies of the original Clean Air Act and set out to further reduce the more blatant pollution problems including acid rain, toxic air emissions and urban air pollution. Not only did the new legislation go a step further in reducing effluent waste, but it also encouraged the use of market-based pollution permits. Although a long time theoretical consideration in the economics literature, the revolutionary new law made it possible for utility companies to trade allowances within their systems and/or buy or sell allowances to and from other affected sources. In addition, it introduced a permit system that would allow the EPA to ensure compliance with all applicable requirements of the Clean Air Act.[5] The new legislation not only made steps to eliminate the restrictive and inefficient command and control policies, but it also gave the EPA a method for efficiently policing pollution control policy.

Arizona's scenic vistas also benefited from the 1990 amendments. The amendments of the Clean Air Act authorized establishment of a "Grand Canyon Visibility Transport Commission (GCVTC) and a Regional Haze Rule promulgated by the EPA, which, in April of 1999, required states to undertake several steps in order to reduce haze in 156 national parks and wilderness areas across the country."[6] The commission's focus was on the multi-state region affecting visibility in the Grand Canyon National Park. Specifically, the commission focused on improving visibility and air quality, while reducing haze in the sixteen national parks and wilderness areas on the Colorado Plateau.[7] The GCVTC set goals of 10 percent of the region's energy supply from renewable energy sources by 2005 and 20 percent by 2015. This is the so-called 10/20 rule. In 1998, renewable energy sources accounted for a little less than 5 percent of the region's total energy supply.[8]

In 1997, the Western Regional Air Partnership (the WRAP) was formed as the successor to the GCTVC. The WRAP continues to focus on improving visibility throughout the West and implementing GCVTC recommendations through several forums and committees including the Air Pollution Prevention Forum[9].

WHY WORRY?

Although governmental policy has come a long way in the last thirty years, many problems still exist. Because Americans today consume more electricity than ever, alternative ways of producing cheap, clean power have become a matter of significant importance. Even though gas and energy prices have been relatively inexpensive in the last few years, it has become increasingly apparent that the current methods of producing energy have fundamental drawbacks and produce severe negative externalities. Fossil fuel consumption using coal, oil and natural gas has led to a barrage of health problems that include respiratory distress with increased cases of asthma in children, visibility issues regardless of geographical region, adverse agricultural impacts from acid rain, damage to the surrounding ecosystems, global climate change and even premature death. Conventional power plants are one of the largest sources of toxic metal compound pollution. Although estimates vary, in 1998, electricity generation released roughly 13 million tons of SO_2 and 6 million tons of NO_x into the atmosphere.[10] Many of these compounds are known or suspected carcinogens and neurotoxins that can cause acute respiratory problems, and aggravate asthma and emphysema.[11] Air quality and the quality of life are being diminished in the name of cheap electric energy.

Furthermore, shifting energy dependence to nuclear generated power has its shortcomings. Debates on what to do with the 42,000 metric tons of highly radioactive by-products still circle with no definite answers in the foreseeable future.[12] These by-products, namely used uranium fuel rods and pellets, are currently warehoused in storage facilities that are only intended as temporary solutions. Although the by-products of nuclear power generation do not directly affect air quality, eliminating nuclear energy would require energy derived from other means with the capacity to fill up the void. In Arizona's case, coal-fired energy generation would step in to fill the void with harmful consequences. However, without having a permanent solution for radioactive waste disposal, relying on nuclear energy to fuel America's energy needs is not a viable option, either.

As a result of the degradation of our air, land and water, along with toxic nuclear waste piling up in power stations throughout the country, it is evident that America must deviate from its current path of energy production. However, implementing an easy, safe and cost-effective solution is something that has been difficult to achieve. Politicians have struggled for answers for almost 30 years and the free market seems to be lacking an answer, as well. As a result, the question we must ask ourselves is how do we produce sustainable electric power that will enable future generations access to the same resources and the same quality of life that are enjoyed today? How do we put a price on the health of our people and our planet that will allow us to economically measure environmental degradation? How do we produce enough energy to power our economy without sacrificing the quality of our air, the health of our people and the stability of our ecosystem? How do we accomplish this in a cost-effective manner that allows consumer and political support?

In theory, these questions are not difficult to answer. With the help of simple economics, logical decision making and political support, we can uncover the answers to most of these questions and make headway in solving a few of the problems. Given the inadequacies of current energy production and given the improving technology trends of renewable energy production, a solution to solve all of these problems is on the near horizon. Investing in renewable energy may very well be the answer.

As a result, this paper will introduce the players in the renewable and non-renewable energy market and describe some theoretical background on the economic issues. Furthermore, this paper will provide information on what should be done to improve air quality and the quality of life for Arizona, suggesting legislative actions, economic incentives and regulatory policies that consumers and the state of Arizona can adopt to increase the use of renewable energy.

AN INTRODUCTION OF THE PLAYERS

Comparing non-renewable derived energy to energy that can be produced from renewable energy sources such as photovoltaic (often called PV or simply, solar) energy, wind energy and biomass-derived energy can be rather complex. However, both types of technologies have their strengths and weaknesses. Both have the potential to provide substantial energy to power the modern world. Both have taken many years of research to improve and both require sizeable investments to put into operation. Their differences lie only in how they produce energy and at what cost. Non-renewable derived energy includes coal-fired and nuclear generated power, with prospects of natural gas fired power plants in the future. One projected natural gas fired plant, known as the Gila Bend Power Project, will likely begin delivering power to the Arizona grid in late Spring 2004. The project consists of three "new technology" Combustion Gas Turbines (CTG) generating a total of 510 megawatts of power.[13] Basically, the CTG's are GE jet turbines powered by natural gas. The gas turbines spin generators, which produce electricity. An added level of efficiency is attained with the implementation of a Heat Recovery Steam Generator (HRSG), which uses the waste exhaust heat from the CTG to generate steam. This steam is collected and used to drive a Steam Turbine Generator (STG), which produces another 335 MW of energy for a total output of 845 MW.[14] Natural gas fired plants are much cleaner and are becoming much more efficient than coal fired power generation. However, natural gas is not a renewable resource and its emissions produce greenhouse gases.

Coal and nuclear powered generators are the current nonrenewable technologies employed in Arizona and produce the bulk of our vast electrical needs.[15] Renewable energy comprises only about 1 percent of electricity generated in Arizona, although this resource remains significantly underdeveloped.[16]

NON-RENEWABLE ENERGY: COAL

There are two serious players in the non-renewable energy market. The first is coal-fired steam turbine generators. Various forms of coal-generated power have been in existence for over a hundred years. The coal powered steam-turbine generators were developed by British engineer Charles A. Parsons in 1884.[17] Later, Nikola Tesla patented his more efficient Tesla turbine in 1921.[18] Since then, coal power generation has evolved and grown significantly, even though the principles and resources used in the last century remain unchanged. Today the largest coal-fired generator in Arizona is the Navajo Generating Station in Page. It began operation in 1974 and produces 2,250-megawatts of energy requiring 1,000 tons of coal per hour.[19]

Although coal has been successful in powering America's energy needs, it has two inherent flaws. For one, it is inefficient. Only about one-third of the energy released in the burning reaction goes to powering light bulbs. The rest of the energy is lost in the form of heat energy and cannot be harnessed given conventional means.

Secondly, burning coal emits a tremendous amount of environmentally devastating by-products and is the reason so many environmental issues have permeated into mainstream society. In particular, coal-burning electric power plants account for roughly 57 percent of the total industrial air pollution in the U.S.[20] About two-thirds of sulfur dioxide, one-third of carbon dioxide emissions and one-quarter of the nitrogen oxide emissions in the U.S. are produced by coal burning.[21] Furthermore, burning coal also results in the emission of fine partulate matter into the atmosphere. These fine particulates become lodged in lung tissue raising lung cancer rates and when combined with SO_2, are linked to at least 64,000 premature deaths annually.[22] Nitrogen oxide (NO_x) and fine airborne particles exacerbate asthma, reduce lung function and cause respiratory diseases and premature death for many thousands of Americans. Every day, 14 people in the United States die from asthma.[23] Smog formed by NO_x and reactive organic gases cause crop, forest and property damage. NO_x is also the primary cause of ozone smog. Each summer, smog provokes 6 million asthma attacks, and results in 160,000 emergency room visits, and 53,000 hospital admissions, in addition to causing visibility issues across the country.[24] SO_2 and NO_x combine with water in the atmosphere to create acid rain. Acid rain acidifies the soils and water supplies killing off plants, fish, and animals that depend on them. Furthermore, global warming is mainly caused by carbon dioxide emissions released when fossil fuels like coal are burnt. In America in 1999, coal-fired power plants alone released 490.5 million metric tons of CO_2 into the atmosphere (32 percent of the total CO_2 emissions for 1999).[25] In addition, coal contains trace amounts of mercury. When thousands of pounds of coal are burned in power plants every hour, mercury becomes a considerable problem. Mercury in freshwater fish has led 40 states to issue warnings about eating contaminated fish.[26] Mercury can cause neurological problems and developmental delays in children. The EPA estimates that at least six million women of childbearing age have levels of mercury in their bodies that exceed what the EPA considers acceptable and that 375,000 babies born each year are at risk of neurological problems due to exposure to mercury in the womb.[27] Last of all, coal mining causes severe erosion, resulting in the leaching of toxic chemicals into nearby streams and aquifers, which pollutes drinking water and destroys habitats. Thomas Casten, author of *Turning Off the Heat*, writes, "In short, the excessively rapid consumption of fossil fuel in old power plants with out-of-date pollution control is causing local and global environmental problems."[28]

NON-RENEWABLE ENERGY: NUCLEAR

Another non-renewable energy resource used to generate power in Arizona is nuclear power. Today there are three nuclear reactors in Arizona located at Palo Verde. Each reactor produces 1,258-megawatts of energy that goes to powering Phoenix, Los Angeles and Las Vegas.[29] While this is a tremendous amount of power generated without visible pollution, it comes at a great cost and with potentially unfathomable negative externalities. As Richard Norgaard illustrates in his book *Development Betrayed*, "Experiments that entail very long time commitments should be avoided. If our ability to foresee the future is limited, then changes that can be undone quickly or will naturally depreciate are preferable."[30] Jane Jacobs echos Norgaard when she writes, "the aims are to make better materials than we manufacture now, but to make them at life-friendly temperatures and without toxic ingredients.[31]" Unfortunately, using radioactive fuel to drive steam turbines entails extremely lengthy time commitments and inexplicable clean up costs. Because the uranium used in nuclear power generation has a useful life of about 10 years and because it has an extremely long radioactive life (upwards of 50,000 years[32]), its effects cannot be undone quickly.

Unfortunately, no headway is being made in disposing of this toxic threat. Currently, most of the high-level radioactive waste is stored at the 72 closed nuclear plant sites around the country. When the uranium fuel rods or pellets are spent, they are moved to storage pools where they cool for approximately ten years and are then moved to steel containers called dry casks. These measures of disposal have proven to be fairly reliable over the last fifty years, however, considering that this waste will continue to be a problem for thousands of years, the long-term outcome for safe storage in this manner is certainly questionable. Adding to the dilemma, the spent fuel is beginning to stack up to the point of maximum capacity in most of the plants. Consequently, the capabilities of safe, short-term storage are beginning to show signs of a catastrophic end. Expansion of these facilities would only slow the problem. If nuclear generated power is used in the way it has been in the past, a permanent disposal solution must be found.

In short, there must be an easier, less environmentally devastating way to power microwaves and TV sets.

RENEWABLE ENERGY: SOLAR

In Arizona, sunlight is a boundless resource with almost limitless potential to generate power. For decades, engineers have been working on ways to catch the sun over a broad area, concentrate it and use it to produce electricity on the same scale as centralized coal or nuclear power plants in hundreds of megawatts at a time. Several pilot plants have been operating in California, some for decades, but so far they have not had enough volume to force costs down to competitive levels.

One of the world's first commercial solar power plants is the Mojave plant, owned by Kramer Junction Company. The Mojave plant operates with five Solar Electric Generating Systems (SEGS) generating electricity for much of southern California. The SEGS plant uses a trough system employing a row of parabolic mirrors that reflect sunlight onto a pipe filled with oil. The concentrated sunlight heats the oil in the pipe, which is used to produce steam, turning a turbine generator. When a few dozen of these trough-mirrors are assembled, up to 30-megawatts of power can be generated.[33] The five SEGS produce up to 180-megawatts of power.[34] The problem with trough technology, though, is that the oil loses its heat too quickly. When the sun goes down, so does the power. The SEGS plant requires supplementary generators that run on natural gas at night and when it gets cloudy.

Another way of producing solar electricity is called a “Power Tower”. Power Towers direct the sun's energy to receivers placed on towers, which heat molten salt to produce heat energy. The “cold” 550ºF salt is pumped into a “hot” 1,050ºF tank for storage, which can then be used to generate power in a steam turbine generator. The benefit of this method of energy production is in the efficiency of thermal storage, which allows electricity to be produced in the evening even as the sun goes down.

Dish systems, although not yet commercially available, may be another potential producer for large quantities of electricity. The building block of such a plant is a parabolic mirror, shaped like a satellite dish that reflects sunlight onto a small generator suspended in front. Water is boiled and steam drives a turbine. Demonstration projects for dish systems are slated to go up later this year in both Arizona and South Africa. Theoretically, a dish configuration would produce more energy per acre than other solar concentrating plants if engineers could figure out a good way of linking many dishes together.

Yet another way to harness the sun’s relentless intensity in Arizona is photovoltaic or PV panels. For years advocates of green power have envisioned that PV technology would become extremely popular because PV panels require no input of resources like fuel or water to power turbines. Additionally, PV systems require minimal maintenance as there are no moving parts and their useful life is exceptionally long. However, their extremely high initial costs coupled with somewhat inconsistent generating capabilities tend to be overshadowed by the historically inexpensive cost of commercial electricity.

Although the initial capital investment of PV panels on private buildings is still fairly expensive, PV technology has been steadily increasing and costs are beginning to decline. Basically, there are two types of construction methods for PV panels.

The first type of PV construction is called “thick crystalline” construction. Using sheets of silicon, sliced from castings, various constructions of thick crystalline have a range of efficiency from 15 percent to 24 percent.[35] Other thick crystalline constructions use ribbons of gallium arsenide achieving a range of 25 to 30 percent efficiency.[36] These systems have historically been used in space power systems, though because of their complex and costly construction, gallium arsenide panels are not yet cost effective from a commercial standpoint.

The second category is “thin film” construction. Using various forms of non-crystalline silicon or polycrystalline, thin film systems have the potential to replace glass windows because of their transparent characteristics. Various forms have achieved 17 percent efficiency, however, commercial modules hover in the 5-7 percent range.[37]

Both types of systems can be incorporated into the construction of private homes. Thick crystalline panels can be set on roofs of houses and thin film panels can replace windows. Depending on budget and energy needs, incorporating a PV system into a private home can cost $1,000 to $40,000 for a complete system. A 5-kilowatt system has the potential to offset all energy needs for a large modern home, while allowing the customer to plug back into the grid and receive money for the energy not used. As noted, incorporating a PV system into a home requires significant additional investment. However, with the state and the federal government offering a variety of tax credits and subsidies, in addition to costs dropping through research and development, installing PV systems into homes and businesses is becoming more and more cost effective.

With over 300 days of strong sunlight available in almost any given region of Arizona, solar energy is a resource just waiting to be tapped into. Considering that 1 kWh produced by PV generation has the potential of offsetting CO_2 emissions by 600 to 2300 kilograms per year,[38] PV technology has the potential to help reduce a multitude of problems, in addition to being a sustainable resource that the people of Arizona can depend on.

RENEWABLE ENERGY: WIND

Another player in the renewable energy market is wind power. As with solar and other types of renewable energy, wind energy has numerous benefits that are not easily quantifiable in the electric power marketplace. Like solar, wind energy provides environmental benefits because it produces no air pollutant emissions. When wind energy is generated and fed into the grid, less energy is generated from non-renewable sources. Reduced generation from fossil fuel power plants will result in lower emissions of NO_x, SO_2, CO_2 and heavy metals such as mercury and lead. In addition, wind generators are modular meaning that their output can range from 100-watts for household use to 1.5-megawatts for commercial use. This allows exceptional customization capabilities for consumers and the electric utility industry.

Wind generation is an extremely efficient way to produce electricity. Wind generated electricity can be produced as low as 5 cents per kilowatt-hour.[39] As a result, wind energy has been the fastest growing source of energy in the world since 1990, increasing at an average rate of over 25 percent per year.[40] Currently, wind energy capacity amounts to about 2,500-megawatts in the United States. Good wind areas, which cover 6 percent of the contiguous U.S. land area, could supply more than one and a half times the 1993 electricity consumption of the entire country.[41] This makes wind power a very competitive player regardless of its clean, renewable advantages over coal and nuclear power. As with other renewable energy, however, wind power generation is a resource that remains significantly underdeveloped.

Private wind generators range in cost from around $1,500 for a 1,000-watt rated wind plant to more than $20,000 for a 10-kilowatt rated generator.[42] Commercial, high output plants use large-diameter, low-rotation-per-minute rotors and are designed to capture energy from low wind speeds. Smaller, less expensive models usually use high-speed, small-diameter rotors powering lightweight generators. These units are mounted on tall poles or towers varying in height depending on the region and the customer's preferences. At current electric rates, wind systems have a simple payback period of 10 to 20 years in most areas.[43] As is the case with solar, net-metering allows customers to sell APS the unused electricity that they generate, in turn speeding up the payback period.

The idea of relying on the wind as a reliable energy source may seem a little risky since wind seems to be so variable from day to day. However, wind actually acts in fairly predictable ways. Analysis of more than a half-century's recorded data, from thousands of sites, shows distinct patterns in both wind direction and speed through the seasons.[44] Although Arizona does not have ideal, wide spread locations for wind energy, sections of eastern Arizona and the Flagstaff area have shown serious potential for commercial development. Additionally, development of small-scale wind driven generators are possible nearly everywhere, as the smaller-scale generators require much less wind velocity to generate power. Wind power generation can be coupled with solar power generation, achieving a very predictable and reliable source of energy.

RENEWABLE ENERGY: BIOENERGY AND BIOMASS

Biomass derived power is another renewable energy source that has potential for development in Arizona. Biomass is any plant material, vegetation or agricultural waste, used as fuel. The current biomass power industry is composed of approximately 350 plants with combined capacity of approximately 7,800-megawatts and employs about 66,000 people.[45] Recently, 45 plants have shut down because of the low cost of competing energy sources. However, with the eventual rising costs of petroleum and coal-fired energy, some of these plants will soon come back online.

Biomass energy has the capacity for semi-large scale development in Arizona. Small-diameter trees, such as the "Black Jack" Ponderosa Pine that are the fuel of high-intensity forest fires, are found extensively throughout regions of Arizona and may be used as biomass fuel in bioenergy plants.[46] The Black Jack Pine contains large percentages of cellulose, hemi cellulose, and lignin that are essential to convert biomass into ethanol, a clean burning fuel with highly efficient burning characteristics. Additionally, when ethanol is produced, the wood fiber is broken up from the biomass mixture creating a by-product called "lignin". Lignin has the same energy content as medium to high-grade coal, but doesn't contain the pollutants of sulfur and nitrogen that have plagued the air quality around northern Arizona for years. With slight modifications, lignin can supplement coal-fired power plants with clean, renewable energy.

Ethanol and combustible lignin have the potential to increase energy output throughout Arizona with renewable, sustainable means. Energy derived from these types of biomass are currently being used in limited quantities for electric power generation throughout the U.S. Still more could be built, given the vast quantities of biomass in the form of municipal wastes, agricultural residues like corn husks and stocks, fast-growing grasses and of course, small-diameter trees. Furthermore, creating a market for small-diameter trees as biomass improves the health of woodland areas by managing densely packed forests that are more susceptible to disease, bug infestation, and wildfire hazards.

Small-scale biomass power plants that range in output from .5 to 5.5-megawatts can be built for around $1 million. A 5.5-megawatt plant can power 5,500 average US homes and can result in payback periods as low as 2 years.[47] For large-scale commercial use, plants producing up to 80-megawatts can be built to power small cities or simply add clean, renewable energy to the grid.

Overall, energy generated from biomass can be produced between 6 and 8 cents per kilowatt-hour, which makes it nearly competitive with non-renewable generated power.[48] This makes it possible for regions like northern Arizona to capitalize on a locally owned facility that would create demand for the renewable, small-diameter trees around the area.

THEORETICAL BACKGROUND

Currently, most forms of renewable energy are not cost effective methods for producing energy because inexpensive electricity can be produced using non-renewable sources. However, the current market system does not take into account many variables that could effectively win over renewable energy as a staple source of electric power generation.

When employing non-renewable energies, such as coal and nuclear, in an unregulated market, private supply and private demand form a fairly inexpensive private equilibrium. More generally, energy suppliers can produce power fairly inexpensively and reap sufficient profits because the current market for energy does not take into account the external costs, such as cleaning up pollution emitted during power generation. These external costs or externalities are costs of market transactions not reflected in the distributed cost of energy. For example, air pollution from a coal-fired power plant can present a health hazard to the neighboring community and lead to additional health care costs. The people neighboring the power plant suffer additional asthma, bronchitis, and even premature mortality as a result of producing electricity by burning coal. The unregulated market provides no signal that the plant ought to control its air emissions, even though the surrounding community is becoming unhealthy as a result of the plant's business. Thus, pollution is a negative externality of producing energy with coal because its cost to society is not reflected in the price of electricity.

There are two separate questions society needs to address with regard to reaching air quality standards. The first is determining the amount of total pollution to allow and the second is determining the most efficient manner to achieve the first.[49] The amount of total effluent, or conversely, the amount of required renewable energy provision, is determined through the political process. For example, the GCVTC guideline of the 10/20 rule stipulates the mandate to the individual states in the WRAP region. The Regional Haze Rule promulgates air quality goals for the distant future concerning the Class I sites.

Once the standards have been set via the political system, cleaning up pollution, efficiently allocating resources and solving many adverse effects of non-renewable energy generation can be accomplished several ways. One way is for utility providers to internalize the externality. Through government control, energy providers could be taxed to cover the all costs incurred by negative externalities, effectively having pollution cleanup costs reflected in the distributed cost of electricity. Furthermore, government organizations could also set limits on the amount of pollution that could be emitted, and could police these regulations. This method of cleaning up pollution would require utility providers to invest significant sums into pollution abatement technologies, thereby cleaning up effluent waste, however, forcing up the final cost of electricity to cover these investments. Basically, the original Clean Air Act used these command and control approaches to reduce industrial pollution in the 1970's. However, as was noted earlier, command and control policies tend to be an inefficient way of allocating resources, because they do not allow market involvement. Solving the pollution problem in America cannot be exclusively accomplished with command and control policies, nor will it be an accepted method from a societal and political standpoint.

Nevertheless, European countries have successfully raised the cost of non-renewable energy generation by recognizing that utility producers should internalize externalities when producing energy with non-renewable methods. Although, this increases the final distributed cost of non-renewable energy, it opens up the door for renewable energy and allows it to be competitive within the energy market. Specifically, Europe has quantified the externality, putting a Euro value on the negative externalities of non-renewable consumption, thereby increasing the consumer cost through taxes on fossil fuels. This has efficiently made renewable energy competitive by leveling the playing field, so to speak.

However, increasing the cost of non-renewable energy in the United States today is not politically viable. Increasing the cost of a gallon of gas to $3 or more is not currently an option and not something that the general public would accept. Similarly, raising the distributed cost of electric power above 15 cents per kilowatt-hour is not a socially or politically viable option either. Internalizing negative externalities forces electricity producers to clean up their act by investing in pollution controlling devices such as precipitators or "scrubbers" to clean up pollution from smoke stacks. The scrubbers, which clean up sulfur and other pollutants, are costly to install and maintain. Because energy producers need to recover these costs, the price of energy goes up.

Additionally, pollution control devices do not completely eliminate pollution; they only curb the pollution problem to a level that is efficient for the producer. As a result, asthma, bronchitis and lung cancer are several problems still exacerbated by air pollution. These problems cost taxpayers millions of dollars in additional health care every year. Still, most utility providers complain of too much internal investment in pollution abatement because investing money in reducing pollution cuts into company profits[50] and raises the cost of electricity.[51] When energy prices begin to rise, consumers generally become upset with government actions. As a result, increasing energy costs through the internalization of externalities is often slow. Furthermore, putting a dollar value on negative externalities tends to be a cumbersome and complex contingent vaulation problem. After all, how do we put a dollar value on having clean air?

Consequently, utility providers in the U.S. are not required to internalize all externalities. Providers can sell energy at 8 to 9 cents per kilowatt-hour, even though covering the cost of negative externalities would require energy to be sold at 15 cents or more per kilowatt-hour.[52] Currently, renewable energy, such as wind, biomass and photovoltaic energy, are produced anywhere from 5 cents to 30 cents per kilowatt-hour.[53] Distributing that power then adds additional cost to the price that consumers pay. To make renewable energy competitive with non-renewable energy and to level the playing field, the cost of renewable energy production must be lowered or the cost of non-renewable energy must be increased.

As noted earlier, the government cannot raise the cost of non-renewable energy. As a result, the only option is to reduce the cost of renewable energy by having the government treat the issue of air quality as a public good. A public good is a good that can be enjoyed by more than one consumer without decreasing the amount enjoyed by rival consumers.[54] A pure public good results in widely consumed external benefits to all persons. If utility providers cannot be forced to internalize pollution costs, then the government must step in to provide health care and improved visibility akin to providing city parks or national defense. Because methods to create public goods are enacted by the government and because, ideally, the government meets the needs of the people, the people must decide what level of pollution is acceptable. Health care for treating the victims of pollution should be provided with the revenue that is generated from taxation. Because renewable energy reduces pollution, thereby reducing health care costs, the government can save on health care by providing consumers with subsidies, tax breaks and tax credits in support of clean, renewable energy.

Even suggesting a complete internalization is a legislator's political suicide, so the theoretical question turns from one of treating air pollution as an externality, to treating air quality as a public good. But this raises the question of: is air quality a true public good? Contemplating the Samuelson[55] concept of the continuum of public/private goods, it seems fairly easy to show that air quality does indeed fall closer to the public good end of the continuum.

Regarding visibility issues, air quality is clearly categorized as a public good in the same sense as parks and education programs. Improving air quality and reducing local and regional haze benefits the public at large. To a lesser extent it benefits those individuals visiting the Class I sites, but public policy has already determined that the National Park system is in fact a public good.

Health benefits are less obviously a public good since not all members of society suffer the respiratory ailments that are reduced through improved air quality. However, when one understands the healthcare system in the United States, this aspect moves closer to the public good end of the spectrum. With 160,000 air related emergency room visits a year, the costs are enormous. Since the US policy is that all individuals arriving at an emergency room are treated, the provision of care is mainly funded through three types of programs. Individuals who have no insurance coverage are mainly covered by public funds. Individuals who have either Medicare or Medicaid are also funded with public funds.

At first glance, individuals with private health insurance may appear to fall toward the private good end of the spectrum, but the insurance policy itself is more akin to a public good. All co-payments are clearly a private good component. However, once a person agrees to participate in an insurance pool, that becomes a public good. The premium does not cover the private good of personal healthcare. Rather, the premium covers the provision of healthcare for all members of the pool. So although there are many different insurance pools, all pools can be treated as being toward the public good end of the Samuelson continuum.

So the issue becomes one of asking whether the glass is half full or half empty? Does society start from a point of having no air pollution and treating effluent as an externality to be internalized, or does society start from a point where air quality is poor and is a public good that needs increased provision? Much of Europe has tackled the problem from the former position and made the production of electricity using dirty fossil fuels very expensive and therefore the production using renewable energy sources competitive. Current, and most likely future, political sentiment in the United States makes the former position highly unlikely. American citizens will not accept $3 per gallon gasoline or 15-20 cent electricity. Recent energy related events have proven this. Therefore it is necessary, since the public sentiment is clearly in favor of improved air quality, to treat the glass as half empty and thereby discover ways to provide the public good of improved air quality.

Indeed, US policy toward air quality/pollution takes both approaches. However, it appears that the levels of internalization, and the corresponding price increases have neared the public's willingness to pay. The Regional Haze Rule and other aspects of the Clean Air Act clearly call for the use of the Best Available Retrofit Technology (BART). With the Mohave Generating Station nearing completion of the installation of "scrubbers," there are few additional opportunities for incorporating BART into the *production* of electricity.[56]

As such public policy is leading toward a two-edged sword approach to improve air quality. The Final Recommendations for the study of renewable energy in the western states concludes: "Most notably, the Forum believes an aggressive renewable portfolio standard (RPS) and a system benefits charge (SBC) are the most effective state policy options in encouraging the growth of renewables."[57]

The RPS is essentially a mandate that providers[58] of electricity within a political unit produce a certain percentage of the available electricity using renewable sources. For example the GCVTC recommended the 10/20 rule for the years 2005 and 2015. The RPS can then be mandated by each state to meet the requirements. The implementation path of the RPS then needs to be discerned.

The SBC is a manner of either internalizing the externality cost or collecting the public good "tax" revenues. Each month a surcharge is added to each end user's electricity bill. The benefits accrue to the user as the producer spends the accumulated funds to either reduce effluent by retrofitting existing facilities, or reduces "dirty" production by building new renewable energy facilities. For example, the main electricity provider in Arizona, Arizona Public Service (APS), is currently building a new solar facility in Prescott. "Much of the cost is covered through a surcharge on electric bills that ranges from about 35 cents per month for residential customers to $39 per month for the largest industrial users. The surcharge generates about $20 million per year."[59]

POLICY INCENTIVES IN ARIZONA

Under state mandates, APS and other providers regulated by the Arizona Corporation Commission are required to provide customers with a certain percentage of energy produced from renewable energy.[60] Using clever investment techniques, the providers have begun providing energy generated from renewables in a semi-cost effective manner. However, Arizona has primarily focused on the development of solar energy at the expense of most other renewable options.

As mentioned above, one method of investment that APS uses is to have users pay a surcharge every month on their energy bills. The surcharge amounts to a few additional cents paid by every customer each month. When compounded, the surcharge provides APS with significant additional funds to invest in renewable energy.

Another way APS promotes renewable energy is their "Solar Partners" program. APS allows customers to purchase 15 to 90 kilowatt-hour blocks of power at a $2.64 to $15.64 monthly premium ensuring that this energy is supplied to them from solar derived sources. APS, in turn, reinvests these payments in the development of PV technology, making solar derived energy cheaper and more plentiful for the future.[61] In 2000, there were only 2,138 partners.[62] Tucson Electric Power (TEP) has a similar project that sells solar generated power in 20 kilowatt-hour blocks. The first block costs $2 per month, and each additional block costs $1.50. TEP also produces electricity using landfill gas.[63] Salt River Project, which does not fall under the RPS regulations in Arizona, also has a program where customers can purchase electricity produced using either solar or landfill gas. Given the cost differential between landfill gas and solar production, the SRP program is relatively inexpensive at $3 per 100 kilowatt-hour block.[64] In comparison, Alliant Energy in Wisconsin offers a variable program based on the percentage of one's electricity bill. As with the Arizona providers, this is a surcharge on the monthly bill of 2 cents per kilowatt-hour.[65]

One aspect of the various partnership agreements that might be of interest is the elasticity of demand issue[66]. The APS program most likely generates less than $100,000 per year given the small number of partners. In essence, APS is asking people to purchase an item that provides very little obvious benefit other than a good feeling that they are helping with air quality. The $2.64 for 15 kWh is a 17.6 cent surcharge. Customers suave enough to appreciate the need for improved air quality are also knowledgeable enough to understand that 15 kWh produces a minimal amount of effluent. As such, the demand for "Green Marketing" programs is likely to be very elastic. Clearly, the partners do not purchase all available blocks – based on current (and future) production. As such it might be presumed that an increase of the kilo-watts purchased for the $2.64/month to say 100 kWh would substantially increase the number of customers and therefore the revenues. The increased revenues could then be used to increase the investment in additional facilities.

Another method APS uses to promote renewable energy is the “buy-down policy.” APS rebates a customer an amount for any solar installation, taking into account that with this installation, the customer no longer needs X amount of power previously consumed from the main grid. This lowers energy requirements for APS, but also reduces required maintenance of the grid. As a result, energy and maintenance costs are reduced. Furthermore, in places where the power grid is non-existent, like certain parts of the Indian reservations of northern Arizona, electrification not only improves the quality of life for the people in those areas, but also provides APS RPS credits.[67]

Formally, the buy-down policy is called the “EPS Credit Purchase Program.” It offers customers a one-time payment of $2 per DC watt for installing a PV system capable of producing five kilowatts or less. For example, if a customer installs a 1-kilowatt set up, the customer will be paid $2,000 by APS.[68] With this program APS receives credit of a 1 kW system for an investment of $2,000 instead of a $7,000 investment. TEP offers up to $2,000 for a minimum 1 kW system[69] SRP seemingly does not have a buy-back program. In comparison, the California Energy Commission provides a buyback rebate of $4.50 per watt up to 50% of the cost of installation.

Another policy APS has implemented to promote renewable energy is called “net-metering.” The term, net-metering, refers to the method of accounting for a system's electricity production and it allows those with self-contained energy producing capabilities, such as solar or wind generators, to plug back into the grid when they are not using the power they generate. Under net-metering, the user sells excess electricity back to the provider when their renewable electric system is producing more energy than is required to operate their home at that time. Typically, a user with a solar system produces excess electricity during the day and then the user purchases electricity during the night.[70] The surplus electricity produced is fed into the utility grid and sold to APS at a discounted rate where customers, in turn, receive a return for each kilowatt-hour generated. Net excess generation is purchased at fixed seasonal rates. Commercial customers may receive 4.4¢/kWh May through October and 3.5¢/kWh for November through April.[71] All other customers receive 4.84¢/kWh May through October and 3.85¢/kWh November through April.[72] Under the Public Utilities Regulation Policy Act (PURPA), the regulatory decision allowing net-metering was enacted by the Arizona Corporation Commission July 27, 1981.[73]

The term “net-metering” used in this sense is seemingly misapplied.[74] As the policy is defined, the provider is able to “purchase” excess electricity at the avoided cost of using fossil or nuclear fuels. The policy does not allow for the user to sell the excess at the actual cost of production. Since the average unit cost of excess solar electricity is substantially higher than the avoided cost, the user of the solar system is in essence making a donation to the provider. But the provider is receiving full credit according to the Renewable Portfolio Standard. As discussed above, the provider is receiving credit for the entire system at $2,000 per kW system and is then able to purchase even more power at a discounted price.[75] Furthermore, the provider could simultaneously be selling the net-metering “purchases” to some of the Solar Partners.

Other incentives in support of renewable energy are state government incentives. State government incentives include sales tax exemptions, income tax credits and personal tax credits. Tax exemptions provide a retail sales tax exemption of up to $5,000 on the purchase of a renewable energy system. Income tax credits can be provided for individuals, partnerships or corporations making investments in renewable energy systems of up to 10 percent of income for the construction of renewable energy systems Personal tax credits which amount to 25 percent, or up to $1,000, of the cost of a solar device can be claimed the year the system is installed.[76] If the credit exceeds a taxpayer’s liability in that year, the unused portion of the credit may be carried forward for up to five years. Additionally, the Department of Commerce offers “Revolving Energy Loans for Arizona” to commercial companies who manufacture renewable energy equipment or use it in their businesses. Under the Arizona Revised Statutes, solar devices can now be sold to consumers without sales tax.

Although these policies are a good overall start, they do have their limitations. The Solar Partners program relies on the goodwill of the customer to pay an additional fee for renewable energy. The buy-down policies require customers to invest in expensive PV systems without truly knowing the benefits these systems promote. Furthermore, net-metering is not cost effective for the private producer and does not promote investment in renewable energy on the private level because of the low wholesale avoided cost that APS pays for this energy. Finally, the majority of consumers are not aware of state tax and subsidy incentive programs.

GOING BEYOND CURRENT POLICY

Although it has become clear that generating electricity using fossil and nuclear fuels has serious consequences, finding efficient ways to produce power in the current market system has proven difficult for society.

Using non-renewable energy to power our world is not sustainable for future generations and is the cause of an ever-growing variety of serious health and visibility problems. On the other hand, renewable energy is clean, sustainable and fairly inexpensive, *after* the sizeable initial investment. The problem is that even with current incentive programs, there are still various barriers hindering the general public's acceptance of renewable energy. As a result, Arizona still has a long way to go until renewable energy is successfully and efficiently implemented as an important source of electricity. The 10/20 guidelines are not 80/90 guidelines. Clearly, fossil fuels must be a vital portion of the electricity matrix into the foreseeable future.

In 1998, renewable energy provided about 4.6 percent of regional electricity in the WRAP region.[77] The Air Pollution Prevention Forum suggests that by 2005, 10 percent of the regional power should be provided by renewable energy and by 2015, 20 percent should be provided. This policy is known as the "10/20 goal.

Going beyond the 10/20 goals, new policies and new policymaking, will allow renewable technology to be incorporated into all facets of the energy market. Through research and development, costs of production can be reduced and efficiency of the equipment can be advanced. The market for renewable energy is rapidly growing. As is true with many new industries, economies of scale and economies of scope offer potentials for further reducing per unit costs. The year 2000 saw a 37% increase in solar production in the OECD countries.[78] In developing countries, growth is expected to be even higher in the future. As the industry grows, economies of scale can be expected to continue. This is true in the production of all renewable energy technologies. In addition to economies of scale, economies of scope are also likely to develop as new and different uses of renewable energy are found. For example, water pumping, highway sign lighting and low wattage fencing (for herd animals) can all use renewable energy sources.

Through education, interest in renewable energy can be expanded informing society of the negative externalities associated with non-renewable energy production and the benefits of renewable energy.[79] Moreover, education will lead to awareness of pollution problems and allow each person to rationally quantify the marginal social and private costs imposed by non-renewable energy production. By offering these newly enlightened citizens tax credits, tax breaks, rebates and subsidies, the investment burden of adopting renewable energy can be relieved. With these steps, new technology can be implemented and employed in a way that will produce clean, sustainable and inexpensive energy, in addition to increasing the standard of living and the quality of life for the people of Arizona.

A STARTING POINT

The first step that should be taken in gaining the overall support of renewable energy generation in Arizona is providing citizens with education and information about renewable energy. Without educational programs informing state citizens on the benefits of renewable energy and the harmful consequences of producing energy from fossil fuel and nuclear derived sources, achieving the 10/20 goals in the commercial market alone will be unlikely. Increasing the knowledge base would allow energy consumers to make informed decisions about the way they buy and use electricity.

As a result, the state of Arizona, providers and renewable energy retailers should incorporate educational programs from classroom to workplace. These programs should be tailored to provide information on the benefits and disadvantages of both renewable and non-renewable energy. The programs should describe externalities involved and provide some statistics to support renewable energy programs. Such programs will inform customers of the impacts their decisions make and the way they can shape the future. The educational programs should include discussions of energy efficiency as well. The best way to reduce effluent is not to produce electricity in the first place!

Once the people of Arizona decide that various forms of renewable energy are a suitable alternative to traditional, non-renewable energy, the 10/20 goals can be reached. To achieve the 10/20 goals, direct and indirect financial incentives need to be employed. The incentives should deal with the cost disadvantage of renewable energy resources compared with non-renewable energy.

According to the *Final Report on Energy Efficiency and Renewable Energy*, written by the Air Pollution Prevention Forum suggests that the two most powerful incentive mechanisms for fostering the growth of renewable energy are the renewable resource portfolio standard (RPS) and the systems benefit charge (SBC).[80] An RPS approach defines the minimum portion of electricity sold into a given jurisdiction that must be provided by defined renewable resources.[81] An SBC approach levies a charge on ratepayers and uses monies collected to support public benefits such as renewable energy.[82] Using these two approaches in policy making, the 10/20 goals can become a tangible reality.

Additionally, removing non-market barriers by expanding tax credit, tax break and subsidy programs to reduce the investment burdens of solar and wind systems should be employed. These programs could be financed through surcharges on current energy bills from sources derived from non-renewable energy production. By removing non-market barriers, demand for large-scale renewable energy and small-scale private renewable energy systems will be created. When demand is increased, commercial interest in providing renewable systems to the consumer will expand and an efficient market for renewable products will be established. In fact, a U.S. Department of Energy Report suggests that, "a large market exists for green products, perhaps as much as 70 percent of all consumers"[83] exists. The creation of an efficient market will dictate further research and development that will improve efficiency and production, bringing down the costs of renewable energy systems over time.

Further policy changes should establish state government renewable energy purchasing requirements. Furthermore, building codes should be changed to incorporate renewable energy systems into newly built homes and businesses. Although construction costs would increase, the newly expanded subsidy programs would ease the investment burden, in addition to creating a new market and many new jobs.

Recall the California Energy Commission buy-down of $4.50/watt for solar PV. Combining this program with energy efficient building and a profitable net-metering program, makes it very reasonable to include a building strategy based on renewable energy and efficiency. As it stands in Arizona, it is merely recommended that buildings be evaluated according to an eight year *or less* payback system[84] even though the typical warranty on a system extends to 15-20 years. Alternatively the Department of Energy recommends using "Life-Cycle cost Analysis" methods for evaluating systems.[85]

Next, barriers to moving renewable generation through the transmission/distribution system should be eliminated, in addition to increasing net-metering paybacks. This would allow the homes and businesses with newly constructed renewable energy systems to plug back into the grid and receive additional income from their systems while providing others with clean, renewable power when it is needed.

Finally, by improving the permitting process for renewable generating facilities, supporting complementary efforts by the federal government, including a national RPS with tradable permits, and adopting state tax incentives for renewable energy projects, Arizona could be a forerunner in establishing renewable energy as the staple source of power for its citizens, while improving air quality throughout Arizona and the Four Corners region.

CONCLUSION

Providing reliable electric power to an ever-growing economy has come a long way in the last hundred years. Vast assortments of technological inventions and innovations have been based on the one fact that electric power is available to the majority of people throughout the United States. With population growth and increasing dependence on these inventions, Americans find themselves hungrily consuming energy like never before. In fact, the U.S.'s annual utility bill amounts to approximately $210 billion per year.[86] Unfortunately, this dependence on current, inefficient and non-renewable energy affects the quality of health and the quality of life throughout the U.S., regardless of region.

Although coal and nuclear generated power's infrastructure is already in place and these non-renewable systems produce power that is cheap and reliable, they are vast polluters, extremely inefficient and even dangerous. Natural gas based electricity production is becoming more and more prevalent. Given the social moods and the economic realities of low cost energy, non-renewables fuels will continue to be the fuels of choice for the next generation. But when taking into consideration the external costs of pollution cleanup, drastically increased health care costs, reduced air quality and a degraded quality of life for the people of Arizona, renewable energy, despite its shortcomings, has the potential to improve such issues. And if Arizona takes the lead in this investment, huge potentials for growth, employment and better air quality are available. The advances in technology, air quality and the like will help Arizona develop the workforce of the 21st Century.

For a variety of reasons, including market cost barriers, antiquated government policy and the overall lack of knowledge by energy consumers, renewable energy has had a tough time finding a niche in the energy marketplace in Arizona .

However, by educating the public, changing policies, eliminating or at least reducing market barriers and encouraging the use of renewable energy, the people of Arizona can allow this wonderful resource to establish a foot hold in the marketplace, in addition to providing jobs, providing sustainable power and improving the quality of life for an entire region's inhabitants.

Arizona has immense potentials for developing renewable energy technology, production and manufacturing. The focus on solar energy is obvious with over 300 days of sunshine across the state per year. But sunshine also produces incredible wind potentials, and the elevation changes across the state intensify the wind possibilities. Current research at Northern Arizona University is investigating geothermal possibilities in the San Francisco Peaks region. The potentials for biomass energy production are also clearly linked to the issues of forest health in Arizona.[87] And as pointed out TEP and SRP produce electricity using landfill gas. The potentials are there to improve health and visibility. One obvious conclusion from this study is that Arizona needs to broaden the renewable energy incentives in much the same way as Nevada[88] has: locally available resources should be developed. Additional policy incentives such as Nevada's commercial and industrial property tax exemptions can also be developed and perhaps extended to residential property.

The need is now, the resources are available and the technology is available.

How can you buy the sky? How can you own the rain and the wind?

—Chief Seattle

ENDNOTES

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[74] Bud Annan has provided much insight on this particular issue. One of the authors enjoyed witnessing a "discussion" between Bud and a manager from one of the Arizona providers when net-metering was informally debated.
[75] Recall the discussion concerning double counting production.
[76]National Renewable Energy Laboratory, Arizona Consumer's Guide to Buying a Solar Electric System, http://www.azsolarcenter.com/design/azguide.pdf, September 2000.
[77] Air Pollution Prevention Forum, Recommendations of Air Pollution Prevention Forum to Increase the Generation of Electricity from Renewable Resources , June 2002, p. iii. www.wrapair.org
[78] http://www.bp.com/centres/energy2002/pagedownloads/solar.pdf
[79] The SES program has found an interesting reality. There are many interesting, fascinating and wonderful curricula developed for K-12 students. There are also interesting and useful curricula for graduate programs. However, from the time kids are intrigued by renewable energy until they become engineers in graduate programs, there are few renewable energy programs. The SES group is diligently working on trying to fill this gap. See the SES web site for some web links: www.cba.nau.edu/ses
[80] Air Pollution Prevention Forum, Recommendations of Air Pollution Prevention Forum to Increase the Generation of Electricity from Renewable Resources , June 2002, p. iii. www.wrapair.org
[81] Air Pollution Prevention Forum, Recommendations of Air Pollution Prevention Forum to Increase the Generation of Electricity from Renewable Resources , June 2002, p. III-3. www.wrapair.org
[82]Air Pollution Prevention Forum, Recommendations of Air Pollution Prevention Forum to Increase the Generation of Electricity from Renewable Resources , June 2002, p. III-6. www.wrapair.org
[83] Mayer, Rudd; Blank, Eric; Udall, Randy; Nielsen, John, Promoting Renewable Energy in a Market Environment: A Community-Based Approach for Aggregating Green Demand, Land and Water Fund of the Rockies, U.S. Department of Energy Report, Boulder, Colorado, May 1997.
[84] http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=AZ05R&state=AZ&CurrentPageID=1
[85] http://www.eren.doe.gov/femp/techassist/life_cycle_cost.html
[86] Usibelli Coal Mine Incorporated, Electricity Growth, 2002, http://www.usibelli.com/coal.html
[87] See Larson, Debra, Smith, Dean Howard, and Smith, Jonathan, "Tragic Fires Open Doors to Opportunity" *Greater Arizona Economic Monitor*, Volume 1, Issue 3, Third Quarter, 2002, for a discussion of the forest issues.

http://bber.cba.nau.edu/monitor/archives/archive_PDF/02Q3issue.pdf. Also see http://www.eri.nau.edu/default1.htm for a more details exposition of the NAU projects on forest restoration.

[88] http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=NV