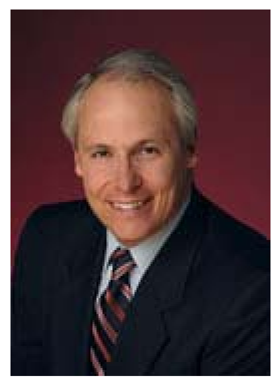
SUSTAINABILITY: A TOWN HALL ON ALBUQUERQUE'S ENERGY FUTURE



Martin J. Chávez, Mayor
The City of Albuquerque

Energy Town Hall Background Report

Prepared By: EECOM, Inc.

February 23-24, 2006

Mayor Martin J. Chávez envisions leading the city of Albuquerque to the forefront of sustainable municipalities in this country. We have all been invited to participate and to formulate strategies to implement this vision. The information in this report is just a glimpse of what Albuquerque has available as Energy opportunities but we hope that it will open the dialog by creating a starting place from which to work. As members of this community, we are proud to have a Mayor who is looking towards the economic, environmental and social opportunities for our and our children's future.

It is a privilege to be a part of this innovative Energy Town Hall.
Thank you for this opportunity
Karen Leigh Cook

Acknowledgements

This report would not be possible if not for the amazing contributions of the following dedicated individuals, representing our corporations, our NGO's and our national laboratories. Without their willingness to allow literary license to EECOM there would be little substance to this report.

Rene Parker, Select Engineering Services, Inc
Glenn W. Kuswa, Sandia National Laboratory
Cathy Wilson, Los Alamos National Laboratory
C. Cameron and M. Hightower, Sandia National Laboratory
Jeffrey Hoffman, National Energy Technology Laboratory
Benjamin Luce, Coalition for Clean & Affordable Energy
Edward Mazria, AIA Mazria Inc. Odems Dzurec
J. Barry Bitzer, Mayor's Chief of Staff, CABQ
Alfredo Santistevan, Director CABQ Environmental Health Department
Fred Mondragon, Director CABQ Economic Development Department
Richard Kennedy, Deputy Director Environmental Health
Jeff Probst, President and CEO Blue Sun Biodiesel
Jack McGowan, President Energy Control, Inc.

This report was produced by EECOM, Inc.
– Karen Leigh Cook, President

Table of Contents

Sustainability: Albuquerque's Energy Future

Executive Summary

The most abundant source of sustainable energy available to Albuquerque is our intelligent and creative citizenry. With your determination Albuquerque can embody the best of a sustainable community committed to ensuring the health of our environment, our economy and our children's future.

Discussions about sustainability are meant to focus our attention on a very basic question: Can our community survive and thrive? Are our systems and practices viable for the long-term? Are we assessing the long-term vitality of both our economic base and environment? Today we are here to do just that.

One of the great challenges of this century is to find ways to provide modern energy and transportation services with as little additional disruption to the Planet as possible. A sustainable city will need a hierarchy of options that maximizes mobility and minimizes energy use, emissions and use of land. Sustainable cities will need to be designed, redesigned and developed to use all critical resources much more efficiently and in a more coordinated fashion.

- Commercial, industrial and residential buildings will need to meet energy standards that far exceed today's best practices in Europe or the U.S.
- All buildings must incorporate energy conscious design, maximum use of natural energy such as daylight, passive solar, and convection cooling and heating.
- We must employ a systematic and consistent reduction of industrial energy consumption, material and water waste.
- An integrated energy supply system that minimizes generation and distribution losses as well as pollution – which should include a widespread use of distributed heating, combined heat and power systems, a smart grid that can support distributed power supplies, and an economically and technically appropriate use of renewable energy resources must be created.
- The gas powered single occupancy SUV must become an endangered species. Energy wise, emissions reducing transportation must become the norm.

This Energy Town Hall will help inform the City of Albuquerque plan. Your challenge is to define for Albuquerque energy strategies in both stationary and mobile applications: which include but are not limited to energy production,

management systems, efficiency, storage, distribution, transportation fuels, systems and management, as well as waste elimination and/or reuse. The Mayor will be convening additional community opportunities to discuss Green Buildings and Zero Waste/Waste to Energy.

Sustainable Community

There are many definitions postulating the meaning of a "Sustainable Community." To embody the unique characteristics of the Albuquerque region and for the purposes of this town Hall we will define it as follows:

> "Sustainable communities are defined as towns and cities that have taken decisive steps to remain healthy over the long term."
>
> Sustainable communities have a strong sense of place. They have a vision that is embraced and actively promoted by all of the key sectors of society, including businesses, environmentalists, civic associations, government agencies and religious organizations. They are places that build on their assets and dare to be innovative. These communities value healthy ecosystems, use resources efficiently and actively seek to retain and enhance a locally based economy. There is a pervasive volunteer spirit that is rewarded by concrete results. Partnerships between government, the business sector, and non-profit organizations are common. Public debate in these communities is engaging, inclusive, and constructive. Unlike traditional community development approaches, sustainability strategies emphasize: the whole community; ecosystem protection; meaningful and broad-based citizen participation; and economic opportunity.

Our area has an economy long dominated by governmental activity, but is becoming increasingly diverse. The most important sectors after government, in terms of value added, include the professional, scientific and technical services, followed by health services, retail trade, and manufacturing, representing more than $6 billion in value added and 140,500 jobs, with about $1.3 billion of value added and some 21,500 jobs contributed by manufacturing.

"Nature's services" are primary drivers of the region's resource economy and quality of life. While solar energy is abundant, water resources have been under some stress. Our revenue window from fossil fuel extraction will soon start to close.

Energy = Water

The availability of adequate water supplies has a profound impact on the availability of energy, and energy production and generation activities impact the availability and quality of water. In today's economies, energy and water are tightly linked, as illustrated in Figure I-1. Each generally requires the other. As these two resources see increasing demand and growing limitations on supply; energy and water must begin to be managed together in order to maintain reliable energy and water supplies and sustain future growth and economic development.

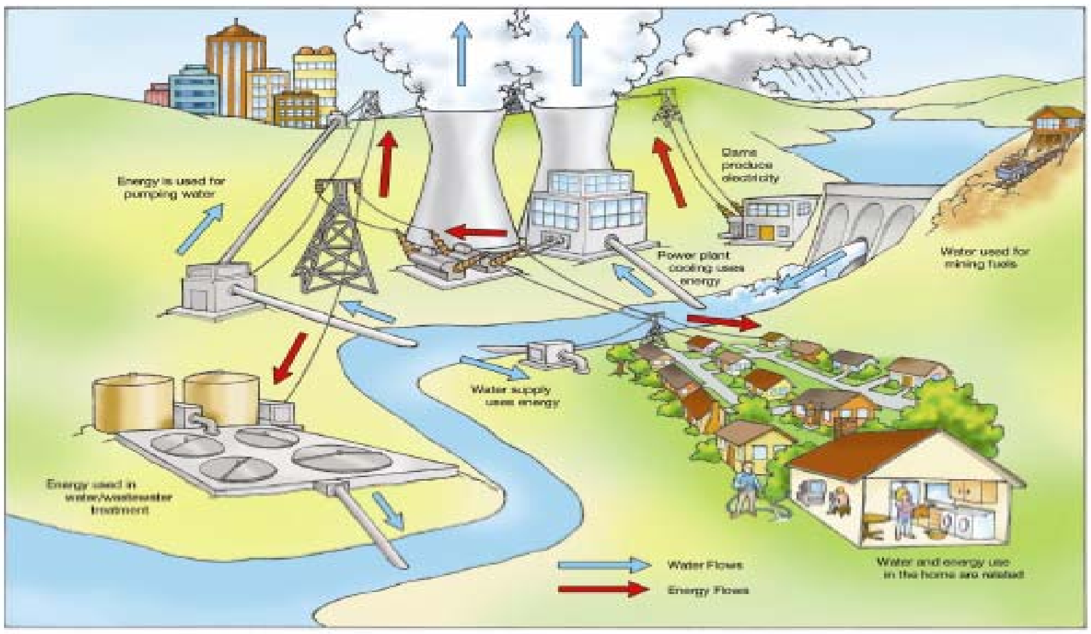


Figure I-1. Examples of Interrelationships Between Water and Energy

At the same time, demand for energy continues to grow. In its reference case, the Energy Information Administration projects that demand for energy supplies from 2003 to 2030 will grow as follows: petroleum, 38 percent; natural gas, 20 percent; coal, 54 percent; nuclear power, 14 percent; and renewable energy, 58 percent. Demand for electricity from all sources is projected to increase by 53 percent (AEO, 2006). Providing this energy will require access to sufficient water resources.

Unfortunately, freshwater withdrawals already exceed available precipitation in many areas across the country. Energy production not only requires and impacts water supply, it can also impact water quality. The energy sector generates waste streams, run-off from mining operations, and “produced” water from oil and gas extraction, and air emissions that may affect downwind watersheds. Examples of energy-water interactions, both large and small, are shown in Table II-1.

Table II-1. Connections Between the Energy Sector and Water Availability and Quality

Energy Element	Connection to Water Quantity	Connection to Water Quality
Energy Extraction and Production		
Oil and Gas Exploration	Water for drilling, completion, and fracturing	Impact on shallow ground water quality
Oil and Gas Production	Large volume of produced, impaired water	Produced water can impact surface and ground water
Coal and Uranium Mining	Mining operations can generate large quantities of water	Tailings and drainage can impact surface and ground water
Electric Power Generation		
Thermo-electric (fossil, biomass, nuclear)	Surface and groundwater for cooling* and scrubbing	Thermal and air emission impacts surface waters and ecology
Hydro-electric	Reservoirs lose large quantities to evaporation	Can impact water temperatures, quality, ecology
Solar PV and Wind	None during operation; minimal water use for panel and blade washing	
Refining and Processing		
Traditional Oil and Gas Refining	Water needed to refine oil and gas	End use can impact water quality
Biofuels and Ethanol	Water for growing and refining	Waste water requires treatment
Synfuels and Hydrogen	Water for synthesis or steam reforming	Waste water treatment
Energy Transportation and Storage		
Energy Pipelines	Water for hydrostatic testing	Waste water requires treatment
Coal Slurry Pipelines	Requires water for slurry transport; water not returned	Final water is poor quality; requires treatment
Barge Transport of Energy	River flows and stages impact fuel delivery	Spills or accidents can impact water quality
Oil and Gas Storage Caverns	Slurry mining of caverns requires large quantities of water	Slurry disposal impacts water quality and ecology

*Includes solar and geothermal steam-electric plants

Just as providing more energy requires more water, providing more water requires more energy. In water scarce regions where desalination and wastewater reuse may provide additional water supplies, more energy will be needed to treat and/or pump those supplies. These energy-water interactions must be carefully considered when developing an energy plan for the future of Albuquerque where water supply is limited.

Energy Challenges/Opportunities

TRANSPORTATION

A recent study of cities all over the world by Peter Newman, Professor of City Policy and Director of the Institute for Sustainability and Technology Policy, at Murdoch University Perth, Australia titled "SUSTAINABLE TRANSPORTATION AND GLOBAL CITIES" concluded the following:

- The patterns of automobile dependence, based on transportation, infrastructure and land use patterns have been shown to follow a consistent story on the global cities we have studied. Their economic and environmental costs show the same pattern. They suggest some overall conclusions. Cities with substantial commitment to sustainable transportation are doing better economically as well as environmentally. There appears to be no obvious gain in economic efficiency from developing automobile dependence in cities, particularly as it is shown in US and Australian cities.

- There are, on the other hand, significant losses in external costs due to automobile dependence which have clear implications for sustainability. There are much higher levels of per capita car use, energy, emissions, and transport deaths. As the global agenda is focusing increasingly on sustainability, there is an obvious need to address these differences by overcoming automobile dependence.

Municipal Infrastructure: Transportation

The City has been actively pursuing improved access to alternative forms of transportation. Albuquerque has done an admirable job in its development of bike trails throughout the city, ranking 14th out of 64 selected southwest cities. The City has also been sustainably proactive in their transit fleet purchases by utilizing hybrid-electric vehicles, Compressed Natural Gas (CNG) cars and buses and the most recent articulated diesel/electric buses. Discussions are underway to develop the state's first hydrogen refueling station in Albuquerque which will utilize existing knowledge and expertise about compressed natural gas to bridge the technology gap to hydrogen. Investing in advanced transportation technologies will afford the City long term flexibility to adopt new more efficient fuels as they are developed. The City is also currently using 10 percent Ethanol, a renewable fuel, as an oxygenate during the winter months and hosts an E85 (85 percent Ethanol/ 15 percent gasoline blend) source at First and Mountain Road. There are also deliveries of B20 (20 percent biodiesel/80 percent diesel) being made to Sandia, Kirtland and PNM within the City.

There is an increasing interest in Renewable Fuels such as Ethanol and Biodiesel both in New Mexico and Nationally because of the reduced emissions and production from domestic resources, which helps to reduce the country's dependence on foreign oil and natural gas. These fuels are currently produced from corn and soy beans however, research is being done to find ways in which to use municipal solid waste, wood, animal and agricultural waste to produce these liquid fuels.

On August 8, 2005, President Bush signed the Energy Policy Act of 2005 (H.R. 6) into law here in Albuquerque. The comprehensive energy legislation includes a nationwide renewable fuels standard (RFS) that will double the use of ethanol and biodiesel by 2012.

Under the RFS, a small percentage of our nation's fuel supply will be provided by renewable, domestic fuels including ethanol and biodiesel, providing a positive roadmap for reduced consumer fuel prices, increased energy security, and growth in rural America. The RFS is the result of several years of negotiations between the ethanol industry, oil industry, Federal government, state interests, environmentalists, agriculture and consumers over the best way to encourage a greater contribution from the renewable fuel industry to our nation's energy needs. A listing of RFS provisions are provided as Appendix A.

The increased use of renewable fuels will expand U.S. fuel supplies while easing an overburdened refining industry. While no new oil refineries have been built in the U.S. since 1976, nearly 100 ethanol production facilities have been built during this time, adding critical volume to the gasoline market. As ethanol and biodiesel are blended with gasoline and diesel after the refining process, they directly increase domestic fuel capacity.

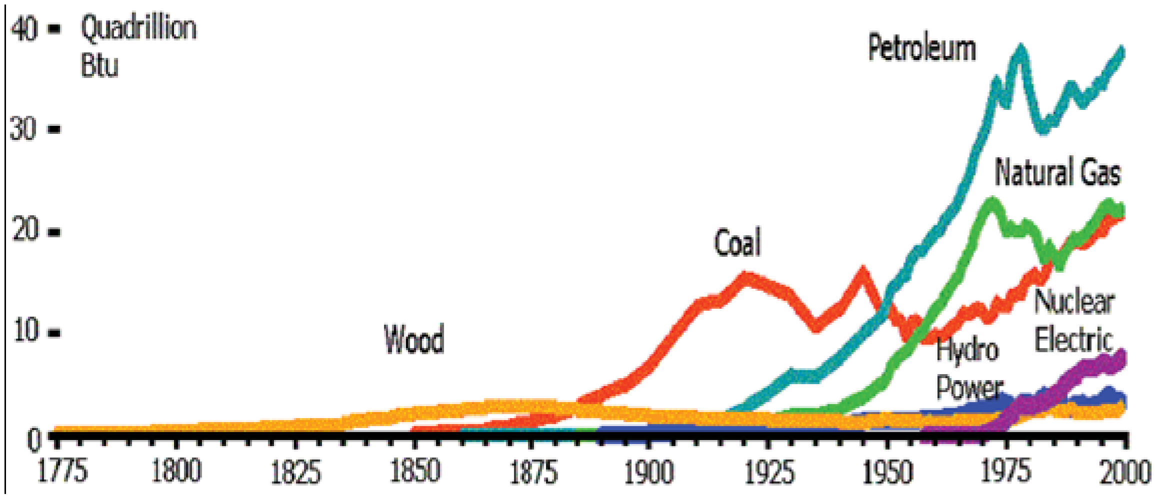
Traffic Management

Recent advances in transit technology, wireless communications and smart urban design, are helping launch a new era of intelligent multi-modal transportation options. This rapidly emerging "network mobility age" has the potential to address transportation problems facing American communities, and save individual consumers thousands of dollars each year. The Internet allows us to consider "mobility substitution" as well as help us move between transportation modes. These new alternatives can improve our quality of life by reducing automobile dependency.

Wireless and computer technologies have become inexpensive and reliable enough that companies can easily monitor vehicles and rent them by using a staff of a few dozen people. City governments seeking to reduce traffic are helping the companies by providing free or subsidized parking and by not charging them hefty car-rental taxes. Some government agencies in Philadelphia; Berkeley, Calif.; and Portland are using the cars to reduce their municipal fleets. Car sharing is not like renting a car from Hertz or Avis. Customers first become members at a cost of $35 to $50 a year. Cars are reserved online or by telephone at rates that start at $7.50 an hour for Flexcar and $8.50 an hour for ZipCar. For a full 24 hours, the price is about $60, including the cost of insurance and fuel.

ENERGY PRODUCTION

Figure 1: Energy Consumption in the United States, 1775-1999



Source: U.S. Department of Energy, Energy Information Administration "Milestones in the History of Energy and its Uses". www.eia.doe.gov/kids/milestones

Energy Efficiency

Annual expenditures for utility bills (energy, water/wastewater, waste treatment) in the region are equivalent to about 1.8% of total value added – and about 27% the entire value-added of the manufacturing sector. Utility expenditures plus fuel expenditures represent 40% of manufacturing value-added (and 2.7% of total value added for the county). This suggests that resource efficiency strategies have significant potential to build value, boost profits and create new jobs without looking outside the region for help. There are also significant potential infrastructure limits around water and wastewater, which also points to eco-efficiency as an important economic development strategy.

The region's higher rate for energy spending suggests strategic resource efficiency as a substantial and untapped source of jobs and cost savings. Many energy, water, and materials efficiency and pollution prevention measures offer rapid paybacks (under two years), and at least in the case of energy efficiency offers greater employment intensity than investment in new capacity. By systematically supporting the resource efficiency efforts of regional companies and agencies, Albuquerque can stretch infrastructure capacity much further, while helping maintain or improve environmental quality, which will aid its recruitment efforts. Furthermore, the region's companies will be increasingly competitive as environmental regulations become tougher and consumers continue to demand more environmentally-friendly products. Alternative financial institutions (like regional development banks), as well as a wide range of Federal, State and private pollution prevention and Eco-Efficiency programs, may be helpful in promoting eco-efficiency.

Waste to Energy

Combustible waste to energy plants operate cleanly around the country. Non-combustible gasification processes that can consume municipal waste and return liquid fuels such as ethanol, hydrogen, clean diesel are being considered and could very well constitute a separate conference.

Resource Efficiency and Pollution Prevention

Businesses can also decrease their reliance on imports by using materials more efficiently. Getting more product and less waste out of each pound of materials, BTU of energy, and gallon of water is simply good business—why should companies spend more on inputs per dollar of value added than they absolutely must? This kind of resource efficiency can also create jobs, shifting dollars from imported resources to local employees, while reducing burdens on the local environment.

Renewable Albuquerque

Albuquerque has world-class renewable energy resources, both locally and via transmission lines to relatively close wind energy resources on New Mexico's Eastern Plains, and solar sites both in the city and to the South. From a technical standpoint, the City could easily become a largely renewable energy powered, heated, and fueled city. Moreover, due to the City's already burgeoning solar energy industries, much of this could be based on locally manufactured and diversified equipment, and made by people who increasingly live in highly sustainable and comfortable homes.

Wind Power and the New Mexico Wind Resource

The wholesale cost of utility-scale wind generation currently costs approximately 2 to 3 cents per kilowatt-hour (with the 1.9 cent per kilowatt-hour available to producers), and continues to decline. This is competitive with both natural gasfired generation and new coal generation. Most of New Mexico's wind power resource is located on the state's eastern plains. The developable potential of this resource is estimated to be at least 20 gigawatts – far more than New Mexico's existing electricity generation capacity from coal. The downside is, of course, that the wind blows only on its own semi random timetable.

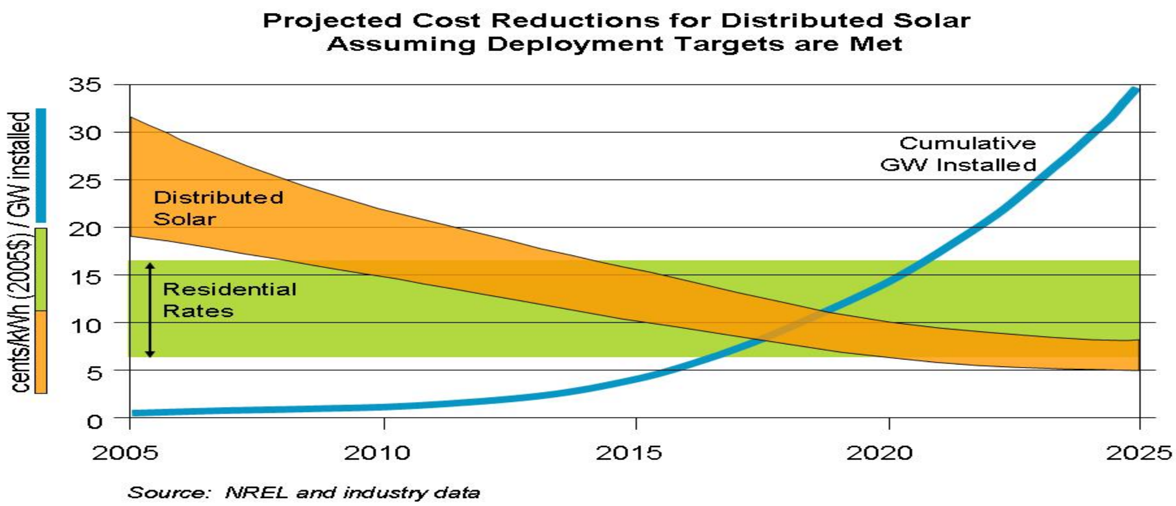
Solar Energy

With the second best solar resource in the Nation (Arizona is first), New Mexico's solar resource is simply staggering. The sunlight falling on New Mexico is approximately 34 times the total energy demand of the United States. Indeed, New Mexico is a potential Solar Saudi Arabia. In the long run, New Mexico's solar resource may well prove to be its best asset. Ambient sunlight is of course an abundant natural resource for Albuquerque, and one that is still significantly under-utilized. A simple calculation to indicate the scale of possible impact: If seven percent of the City's total area (or about 10% of the county's commercial, residential and industrial land area) was equipped with photovoltaic panels operating at 10% efficiency, the city could generate 145% of its electricity consumption – an estimated $510 million annual economic value. (http://rredc.nrel.gov/solar/old_data/nsrdb/bluebook/).

Current and Future Costs of Solar Power

Photovoltaics, which use a solid-state (semiconductor) process to convert sunlight directly into electricity, presently cost approximately 26 cents per kilowatt-hour, about three times the cost of conventional retail power (8-9 cents per kilowatt-hour in New Mexico). This may seem high, but its greatly decreased from a factor of well over 20 in the early 1980's (one should be careful to compare the cost of PV with retail power, because PV is usually located on-site, and can be used to offset retail power costs directly via "net-metering"). Another way to give these costs is in terms of the peak output of a PV system. A typical system today, for example, costs about $9/watt (total installation cost). A typical system for an efficient home is about 2 kilowatts, which would therefore cost about $18,000. A detailed PV system cost example, including the effect of various incentives available today, is provided below in Appendix B.

Recent estimates of the cost trajectory of photovoltaics suggest that photovoltaics will become directly competitive with retail rates in New Mexico around 2015. The following graph, for example, shows the cost trajectory recently computed by the National Renewable Energy Laboratory for the Western Governor's Association. In particular, it suggests that the lower end of distributed solar costs will intersect 9 cents/kWh in about 2016.



Approximately 31 states, including New Mexico, have some type or types of financial incentives for photovoltaics to close the cost gap, or partially close it, in an artificial way, so as to keep the industry growing and keep costs on their current downward trajectory. A complete listing of these policies can be found at the Database of State Incentives for Renewable Energy, at www.dsireusa.org.

Concentrating Solar Power, or CSP technologies, which use mirrors in various ways to focus light to produce heat for electricity generation, is estimated by various studies, suggest that CSP could become cost competitive with conventional sources if CSP is developed to a scale of several thousand megawatts or more. Currently there are only several hundred megawatts operating in California, but these initial plants have performed (and are still performing) very well, and there are many projects now under development around the World. A large CSP plant could conceivably serve Albuquerque by 2015. CSP technologies, in particular, can incorporate *energy storage*, which means they could be used very effectively in the near term to offset conventional power generation, including coal generation. Sandia Labs, for example, has developed an energy storage approach for CSP plants that involves melting a particular kind of salt. Thermal energy is stored via the *latent heat* needed to melt the salt at constant temperature. This technology was successfully tested at Solar Two in Barstow California.

New Mexico's Solar Industry

There is small but healthy photovoltaic installation industry in New Mexico, and a very rapidly growing and vibrant PV manufacturing industry, along with some CSP related companies, which all together are now doing over $100 million in business each year. Listings of solar companies in New Mexico can be found on the website of the Renewable Energy Industries Association of New Mexico at www.REIA-NM.org, and more broadly in the Professionals Directory published by the New Mexico Solar Energy Association at www.NMSEA.org, and at www.findsolar.com. In the 2006 Legislative session, the state passed a solar tax credit bill that will greatly enhance opportunities for implementation. A brief summary of the tax credit is attached as Appendix D.

Solar Thermal Systems

Active solar thermal systems, including solar hot water systems (for both space heating and domestic hot water), and solar hot air systems, are already cost effective. A detailed solar thermal system cost example is provided below in Appendix C. The solar thermal industry, unfortunately, currently suffers severely from its small size, lack of competitiveness, and lack of consumer awareness. Several very competent companies exist in New Mexico, fortunately, and are growing rapidly (see the same sources listed above to locate these companies). New tax incentives, both Federal and State, are now available, and are expected to help greatly in ramping up the solar thermal industry over the next ten years. Major issues with active solar thermal technologies in the past were the substandard equipment and installation practices that emerged (in addition to much successful solar thermal technology) under the ridiculously generous solar tax credits of the 1980s. Today, a national certification corporation for solar thermal panels exists (www.solar-rating.org), and a national solar installer training certification program for both solar thermal and photovoltaics has been established (www.NABCEP.org). These, plus the much better technology of today, and much more careful design of incentives, have largely put the problems of the past with solar to rest.

Solar to Hydrogen

With respect to hydrogen specifically, Albuquerque could contribute greatly to demonstrating the viability of utilizing renewable energy, especially solar and wind, to produce hydrogen via electrolysis, and utilize that hydrogen-combustion vehicles (including hybrids), fuel cell vehicles, and stationary fuel cells in buildings. The fundamental physics and economics of a “renewable-hydrogen economy” are extremely promising: The “well-to-wheels” cost of renewable-hydrogen fueled vehicles could actually be competitive with today’s gasoline prices if the hydrogen hybrid vehicles, hydrogen production and filling stations, and the renewable energy sources to power them, are all refined sufficiently and implemented on a large scale.

Fortunately, hydrogen hybrid vehicles are already under intense development by auto manufacturers (e.g. Ford's H2RV – Hydrogen Hybrid Research Vehicle), demonstrating that it is not necessary to delay the development of a renewable hydrogen economy for another decade or more while waiting for fuel cell vehicles to become available. A near term step towards making a renewable-hydrogen economy based on such hydrogen hybrids a reality may be the emergence of "plug-in hybrids". These vehicles are hybrid vehicles with enhanced battery storage, which enables most local transportation to be carried out with purely electrical drive. The widespread deployment of grid-tied photovoltaics along with such vehicles would actually enable most local transportation in sunny cities such as Albuquerque to be powered by solar, and in the relatively near future.

While this may strike some as a very economically dubious sounding idea, photovoltaic powered electric transportation is, surprisingly, already competitive with today's gasoline prices. This is because the very high efficiency of electric transportation (60% or higher) more than compensates for the relatively high cost of photovoltaic power today, relative to the low efficiency of today's typical internal combustion engines. The idea of solar powered plug-in hybrids is therefore not outlandish at all from a technical and economic standpoint, and widespread use of plug-in hybrids would lead directly to the next step of replacing the gasoline-powered engine with a renewable-hydrogen fueled combustion engine, so that long distance transportation can also be based on renewable energy. Many groups (www.CalCars.org) and some cities (e.g. Austin) presently have initiatives underway to convince auto-makers to produce plug-in hybrids.

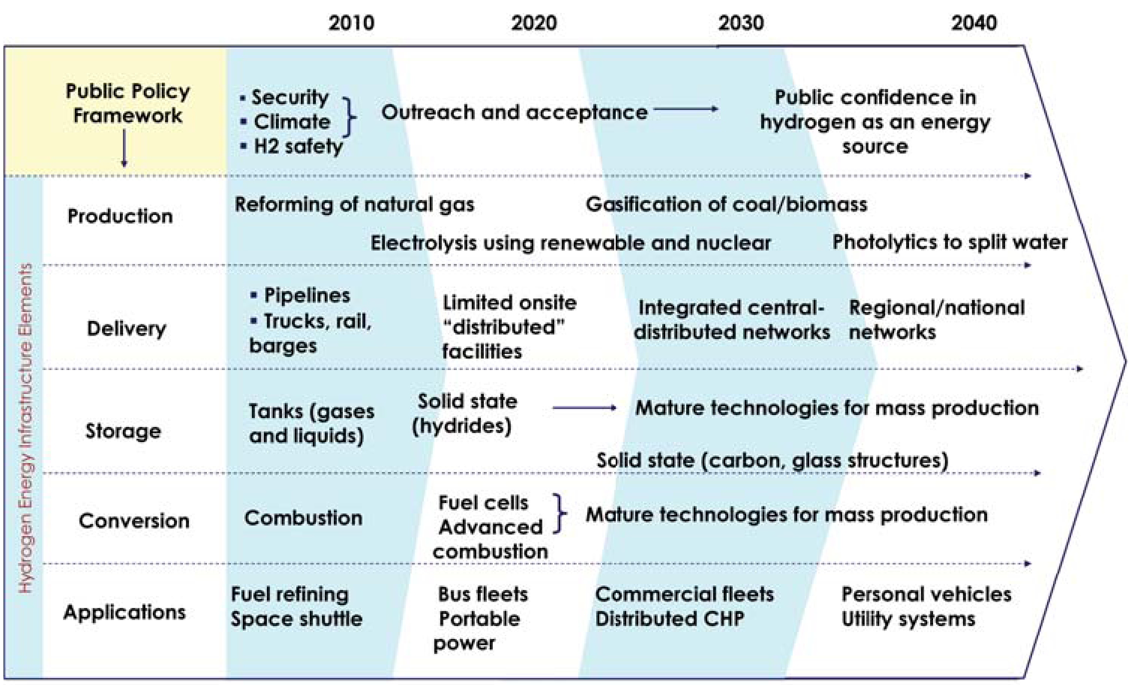
Energy Storage Technologies

Another critical step that needs to be taken to further engender a clean energy future is the serious development of new energy storage technologies for compressed air for wind power, hydrogen and advanced battery storage for solar, and molten salt (thermal storage) for concentrating solar power. Renewable energy will simply not advance beyond a minority position unless storage technologies are perfected and implemented on a large scale. The development of energy storage also advances clean transportation sector as well, and can therefore have profound impacts on increasing the market for renewable energy, and lowering emissions from fossil fuel use.

The Hydrogen Economy

Right now we may be standing on the brink of the next big energy transition, or diversification. The international community recognizes hydrogen as a key component to a clean, sustainable energy system. This future hydrogen economy features hydrogen as an energy carrier in the stationary power, transportation, industrial, residential and commercial sectors. As technology matures, hydrogen will be produced mainly using clean technologies like electrolysis from renewables (including nuclear), or reformation of fossil feedstocks with carbon sequestration. It may be stored, transported by truck or pipeline, and used in a fuel cell, turbine or engine to generate an electric current with water as the principal by-product.

Transition to Hydrogen Economy



Source: U.S. Department of Energy, Hydrogen Posture Plan

As with all energy transitions, the transition to a hydrogen economy will take time and occur in phases. Technological advances and market acceptance are expected to define the phases. In addition, a corresponding education effort in hydrogen safety will ensure public readiness as hydrogen becomes increasingly available. Government, industry and the public will all play vital roles. Government will be a major supporter of technology research and development as well as the development of codes and standards for the safe use of hydrogen. Governments also can use policy to stimulate the marketplace and to encourage "early adoption" of hydrogen energy technologies. Industry's role is to determine when technologies are ready to transition to the marketplace and in establishing the manufacturing base to supply the component technologies. Together, industry and the public will define consumer requirements and market acceptance of the technologies.

Transmission/Grid Management

There is going to be a demonstration project in the city of Albuquerque that is called: GridWise; which is an initiative to stimulate the development and adoption of an intelligent energy system that enables more effective use of the current U.S. Electric infrastructure System. This will result in significant opportunities for energy efficiency. Of equal importance it can result in a more reliable Grid. This GridWise demonstration project is being sponsored by the new Department of Energy Office of Electricity Transmission and Distribution (DOE O-ETD), UNM, PNM and Energy Control, Inc.

This will demonstrate and accelerate the development of an entirely new industry, electronic "e" energy services. E-energy services could include a host of services for energy efficiency, facility management and intelligent buildings. GridWise goals straddle supply and demand side, as well as the need for new sources of energy. There is little debate that, short of fusion, the greatest opportunity for a new energy source is still efficiency. Yet there has never been a way to harness and reroute efficiency to reduce electric use at a specific time. Smart systems to manage energy use in buildings, campuses and residences would make this possible through an electronic information exchange between utilities and customers. E-energy services are already developing, and the focus is not on products per se, but on new solutions and services enabled by smart, networked products that are deeply integrated into an equally new real-time enterprise.

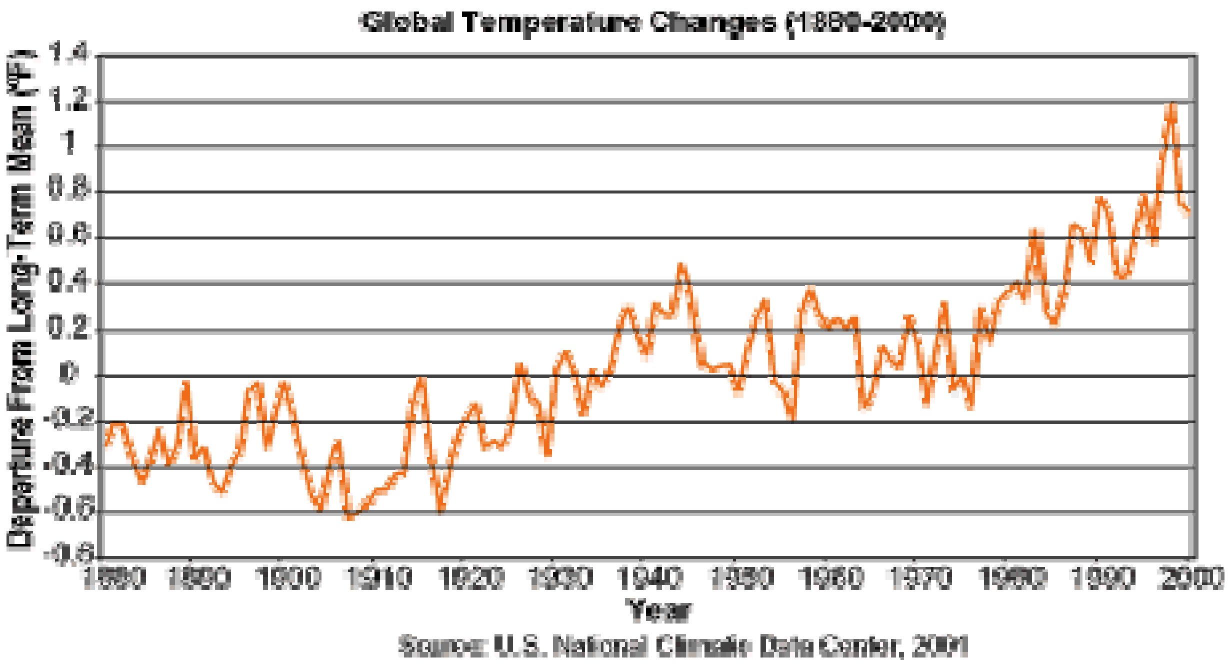
Some of the opportunities and applications that are being explored are:

- Ability to select varying levels of quality of electric service
- Smart loads that handle outages or service reductions gracefully
- Price responsive demands for energy markets/contracts or reserve/emergency markets/contracts
- Congestion relief
- Emergency response to natural events or deliberate destructive actions

GLOBAL WARMING

An Introduction

According to the National Academy of Sciences, the Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with accelerated warming during the past two decades. There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities. Human activities have altered the chemical composition of the atmosphere through the buildup of greenhouse gases – primarily carbon dioxide, methane, and nitrous oxide. The heat-trapping property of these gases is undisputed although uncertainties exist about exactly how earth's climate responds to them.



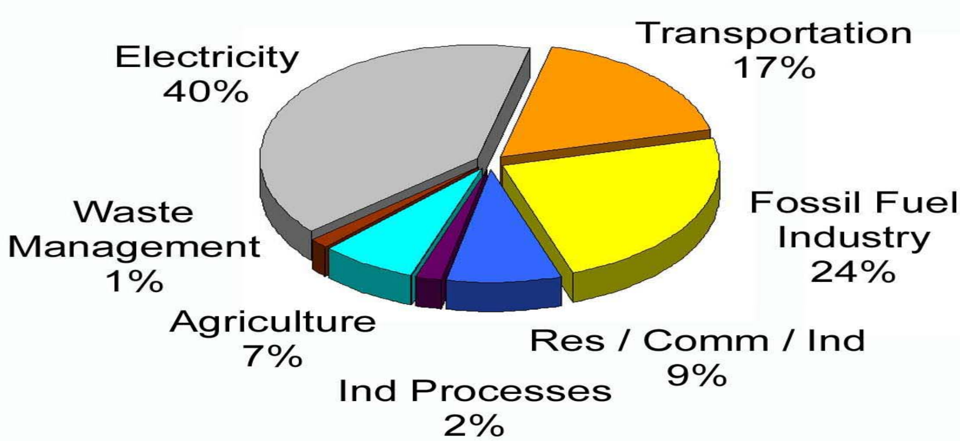
Our Changing Atmosphere

Energy from the sun drives the earth's weather and climate, and heats the earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat somewhat like the glass panels of a greenhouse. Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the earth's average temperature is a more hospitable 60°F. However, problems may arise when the atmospheric concentration of greenhouse gases increases.

Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15%. These increases have enhanced the heat-trapping capability of the earth's atmosphere. Sulfate aerosols, a common air pollutant, cool the atmosphere by reflecting light back into space; however, sulfates are short-lived in the atmosphere and vary regionally.

Why are greenhouse gas concentrations increasing? Scientists generally believe that the combustion of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide. Plant respiration and the decomposition of organic matter release more than 10 times the CO2 released by human activities; but these releases have generally been in balance during the centuries leading up to the industrial revolution with carbon dioxide absorbed by terrestrial vegetation and the oceans.

What has changed in the last few hundred years is the additional release of carbon dioxide by human activities. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for about 98% of U.S. carbon dioxide emissions, 24% of methane emissions, and 18% of nitrous oxide emissions. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of emissions. In 1997, the United States emitted about one-fifth of total global greenhouse gases.



NEW MEXICO
GREENHOUSE GAS INVENTORY
2000

CITY OF ALBUQUERQUE CURRENT INIATIIVES

Renewable Energy Trends and highlights to date:

- In 1976, the City constructed a co-generation facility at Southside Water Reclamation Plant that produces electricity from biogas and is a Federal Energy Regulatory Commission Qualified Facility.

- In 2006, the City completed a 70 kilowatt microturbine landfill gas-to-energy project at the Los Angeles Landfill (RV area of the Balloon Fiesta Park). A first of its kind in New Mexico, the project was funded in part by a grant from the State of New Mexico. The system is operational, powering the methane extraction system, flare station and groundwater remediation system at the landfill. The remaining electricity is being sold to Public Service Company of New Mexico. Eventually this generating station will be capable of providing electricity for the RV area during the Albuquerque Balloon Fiesta.

- The City is currently working to secure federal and state funding for additional landfill gas-to-energy projects, including:

    - Hybrid landfill gas-to-energy and photovoltaic array (solar) at Sandia Science & Technology Park;
    - Landfill gas-to-energy project at the Cerro Colorado Landfill to utilize the landfill gas currently being flared as a renewable energy source; and,
    - An additional project at the Los Angeles Landfill to utilize the remainder of the gas not currently used by the current system.

- Albuquerque is in partnership with U.S. DOE "Million Solar Roofs" program in which solar thermal and solar photovoltaic systems will be installed in public buildings. Currently installing solar pool heating and photovoltaic systems in 5 City swimming pools.

- The City maintains annual utility bills under $17 million despite continuously increasing energy costs

- Mayor Martin J. Chávez facilitated partnership between UNM and Center for Research and Development in Electrochemistry in Queretaro, Mexico to promote water treatment and solar energy.

- City has partnered with Sacred Power Corporation (a Native American owned and operated small business with a charter to provide renewable and distributive energy and telecommunications solutions), located in Albuquerque, New Mexico, to build a photovoltaic/fuel cell hybrid demonstration project. This mobile solar fuel cell project will be placed at city facilities/special events to demonstrate solar technology and to increase solar awareness.

- City of Albuquerque Aviation Department engaged in public/private partnership to develop hydrogen production, storage and dispensing facility.

In addition to renewable energy use, the City is actively focusing on energy conservation in city operations and the community as a whole, some of the City accomplishments over the past few years includes:

Public Outreach & Education Trends and highlights to date:

- Albuquerque's Energy Conservation Council is a 9-member citizen board that provides education and awareness through workshops, newsletters, television program, web site, and monthly public meetings.

- "Energy Matters" television series is broadcast on government access television in Albuquerque and throughout State of New Mexico.

- City of Albuquerque web site provides current information on energy conservation techniques, projects, activities and tools.

- Instituted a program that provides a free set of four TireMinders® to the first 1000 residents that participate in the Air Aware project. TireMinders® are new tools that help commuters maintain the proper tire pressure in their vehicle, thereby achieving improved fuel economy and generating less air pollution

- Land Use Measures (LUMs) under development to determine how land use development practices (such as transit-oriented, mixed use and traditional neighborhood development) can reduce gasoline consumption and vehicle miles traveled.

Transportation and Fuel Trends and highlights to date:

- Albuquerque is active member of U.S. DOE Clean Cities program that promotes alternative fuels and vehicles, and idle reduction.

- In partnership with the Federal and State governments, a detailed financial plan will be developed for a light rail system, for approval by the FTA by June 2006.

- Albuquerque initiated a Rapid Transit Project which is the first phase of a regional rapid transit system planned for implementation by the City of Albuquerque. The proposed project is for a light rail transit (LRT) line. Bus Rapid Transit (BRT) is being considered as an alternative to LRT.

- Construction on the Southwest Mesa Park & Ride, and plans for additional park and ride facilities, to be complete by end of first quarter FY06.

- Albuquerque launched "Rapid Ride" public transportation using articulated diesel/electric buses in Albuquerque in December 2004.

- Albuquerque currently has 54 hybrid buses.

- Pilot program implemented in FY05 to provide weekend late-night Rapid Ride service to encourage use of mass transit for family, cultural and community entertainment and events.

- Rapid Ride Business Partnership Program (BPP) has been initiated to create a cooperative marketing environment where businesses promote Rapid Ride service in return for ABQ RIDE's official recognition of their contributions via interior bus panels, web site and other promotional materials.

- "Carpool Now" program promotes alternative mode of transportation through computerized matching of riders.

- 650 vehicles have been converted to biodiesel.

- All three of the City's main fueling stations now dispense B-20 biodiesel; preliminary indications are that conversion to B-20 results in a 15% increase in fuel efficiency.

- CNG fueling station constructed at airport is primary fuel source for rental car shuttles;

- The City Aviation Department is working with the National Automotive Center and major fuel company to construct pilot hydrogen fueling facility adjacent to existing CNG facility; project is in early negotiating phase.

- Because improper tire pressure is the biggest factor in increased gas consumption, a tire pressure maintenance program has been implemented using special valve caps—maintaining proper tire pressure will not only conserve gas, but will likely also extend tire life.
- There are currently 98 dedicated compressed natural gas vehicles in the City fleet, and 24 hybrid vehicles; the hybrids are achieving double the gas mileage as the conventional gasoline fleet vehicles; there are 256 dual fuel E85 and 6 dual fuel CNG vehicles.

Land Use and Building Practices Trends and highlights to date:

- An ordinance adopted in 2003 reserves 1% of general obligation bonds capital fund specifically for energy conservation projects.

- Energy Conservation Council provides mechanism for community leadership in energy conservation.

- To date, approximately 40% energy cost reduction by retrofitting conventional traffic signals to LED technology.

- Adopted Albuquerque/Bernalillo County Comprehensive

- Plan Linking of land use and transportation planning through mixed use development projects such as East Downtown.

- Centers & Corridors section guides spatial change and promotes housing and employment centers along transit corridors.

- Plan promotes compact form to enable more walking and less driving, as well as decreased water use through more compact urban living and less landscaping.

- Elements of a Planned Growth Strategy have been adopted to provide an urban growth land use plan; zoning and design guidelines using Traditional Neighborhood Development principles; financial requirements for infrastructure to address rehabilitation, deficiencies and growth needs; development impact fees; concurrency approaches to insure that adequate infrastructure and other facilities, including parks and schools, are available to support new development; development and transportation linkages; housing affordability; legally-defined Planned Communities in the Comprehensive Plan Reserve and Rural Areas; joint City–County–APS coordination; regionalism.

- In FY06, legislation will be proposed to inventory surface parking lots in downtown Albuquerque and initiate an effort to redevelop them with higher density residential and mixed use projects.

- In-house lighting retrofit team activated.

- City of Albuquerque Housing Services entered into energy performance contracting for housing units.

- Mayor Martin J. Chávez issued executive order establishing high performance green building standards for City projects, including requirements to meet or exceed LEED Silver rating.

- Executive order also requires coordination of green building codes to promote high performance buildings.

- 1st City LEED project design is in process for Albuquerque Fire Department command station.

- Establishment of a Sustainable Business Network to encourage green building technology and business development.

- Beginning July 1, 2005, impact fees (Planned Growth Strategy) are assessed on all building permit applications.

LOOKING TOWARD THE FUTURE

The City will continue to focus on increasing renewable energy use and overall energy conservation throughout City operations and our community.

ENERGY INNOVATION and our INSTITUTIONS

Albuquerque has a long history of providing technical testing and evaluation of new processes for both the private and public sectors. We are well regarded for enabling technological advancements in the development of energy sources, energy technologies, energy efficiencies and innovations. Some of our scientific and technical institutions related to Energy include:

- **SANDIA NATIONAL LABORATORIES (SNL)**

Sandia has an extensive renewable energy program that dates back to the 1970s. The lab is nationally and internationally recognized for its work in renewable energy, and is the largest renewable energy research and engineering program in the State of New Mexico. Its focus is on commercialization of technologies geared toward utility-scale applications. In addition to Sandia's research of solar photovoltaics (PV) and concentrated solar (solar thermal), it also conducts research in the areas of wind energy, energy storage systems, geothermal systems, solar buildings, and distributed energy. Sandia received over $30 million in federal funding for renewable energy research in 2004. Sandia is advancing the use of hydrogen as an energy carrier through a broad spectrum of research and engineering projects that are integral to the development of the hydrogen economy. Sandia's work ranges from fundamental research on hydrogen properties to comprehensive systems engineering of hydrogen technologies.

- **LOS ALAMOS NATIONAL LABORATORY (LANL)**

LANL also has a long history of renewable energy research that dates back to the 1970s when the Lab played a key role in developing the initial technologies for the renewable areas of geothermal and solar. In the intervening years Los Alamos has continued to evolve the fundamental scientific base necessary for developing the next generation of renewable energy technologies to help lower costs to a more competitive level. Los Alamos possesses much of the expertise and many of the capabilities needed to advance renewable energy technologies, including catalyst chemistry, computer and computational sciences, condensed matter, fuel cells, geological and environmental sciences, hydrodynamics, hydrogen handling, nanophotonics, nanoelectronics, bio-mimetic and bio-inspired materials, complex functional materials, nanostructured materials, sensors, nanoscale interfaces, nanomechanics, and materials integration at the nanoscale, remote sensing, theory and simulation, and thermoacoustics. Los Alamos has one of the oldest and largest fuel cell Research and Development (R&D) programs in the country. Located in the Materials Science Division, this program has been active for over 27 years and has a portfolio of 25 active patents, 16 of which are currently licensed.

- **NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY**

New Mexico Tech administers a research and development organization called the Institute for Engineering Research and Applications which focuses on the environment, power and energy, and homeland defense.

- **NEW MEXICO STATE UNIVERSITY**

NMSU hosts two important centers for renewable energy research. The Southwest Technology Development Institute (SWTDI) provides scientific and engineering support for renewable energy research. SWTDI conducts activities in a number of different areas, among them: photovoltaic systems, wind energy, environmental systems, and geothermal energy. The SWTDI manages and operates the NMSU Geothermal Greenhouse Facility on the campus of New Mexico State University. The geothermally-heated greenhouse research and incubator facility includes two 6,000-square-foot greenhouses and features innovative heating and cooling systems, fully computerized environmental controls, and state-of-the-art film cover materials.

- **UNIVERSITY OF NEW MEXICO (UNM)**

The research and education programs at UNM are based in the Departments of Chemical and Nuclear Engineering, Mechanical Engineering, Chemistry and the Center for Micro-Engineered Materials.

Appendix: A The RFS provisions are as follows:

- Establishes an RFS that starts at 4 billion gallons in 2006 and increases to 7.5 billion gallons in 2012.
- Provides for 2.78% by volume renewable fuel use in 2006 if federal regulations have not yet been promulgated by the U.S. Environmental Protection Agency.
- Provides that beginning in 2013, a minimum of 250 million gallons a year of cellulosic derived ethanol be included in the RFS.
- Provides refiners flexibility by creating a credit trading program that allows refiners to use renewable fuels where and when it is most efficient and cost-effective for them to do so. The credit trading program will result in lower costs to refiners and thus, consumers. RFS credits have a lifespan of 12 months. Every gallon of cellulose-derived ethanol is equal to 2.5 gallons of renewable fuel.
- The law exempts small refineries (defined as facilities where the average daily crude oil throughput does not exceed 75,000 barrels per day) from the RFS program until January 1, 2011. Small refineries are able to opt in to the program and generate credits as do other refineries.
- Requires annual studies on seasonal variations in renewable fuel use. Requires regulations to ensure that at least 25% of the annual renewable fuel obligation be met in each season should seasonal variations exist. California is exempted, but refiners in the state must still use the requisite amount of renewable fuels in any given year.
- Protects consumers with a waiver provision in the event the economy or environment would be severely harmed because of the RFS.
- The reformulated gasoline (RFG) 2.0 wt. % oxygenate standard under the Clean Air Act is eliminated 270 days after enactment.
- Enhances the air quality performance standards established in the RFG program.
- Creates grant and loan guarantee programs for cellulose ethanol.
- Creates grant and loan programs for ethanol production from sugar.

The legislation does not ban MTBE nor provide liability protection or a remediation fund.

Appendix B: Photovoltaic System Example

Assumptions:

- **Peak output of system:** 2 kilowatts (nominal residential system size)
- **Installed cost:** $9/watt (i.e. total system cost for this example is $18,000)
- **Average daily output of 1 kilowatt of PV in NM:** 4.5 kWh/day (i.e. system output in this example is 9 kWh/day).
- **System lifetime:** 25 years
- **Average utility power cost:** $.10/kWh.
- **Value of PNM PV buyback program:** $.13/kWh through 2018.
- **System is located in PNM's territory, and also "net-metered".**

Total Value of a 30% Tax Incentive:

- Total installed system cost is $18,000.
- 30% of $18,000 = **$5,400.**

Total Value of "net-metering" benefit over 25 years:

- Total number of solar kWh generated = 25 years x 365 days x 9 kWh/day = 82,125 kWh.
- Total value of avoided utility power purchased over 25 years: 82,125 kWh x $.10/kWh = **$8,215.**

Total Value of PNM RECs Buyback Incentive (assuming system is installed in 2006):

- Total number of years of incentive = 12 years (2018-2006).
- Total number of solar kWh generated over 12 years = 12 years x 365 days x 9 kWh/day = 39,420 kWh.
- Total value of Buyback Incentive: 39,420 kWh x $.13/kWh = **$5,125.**

Total Incentives over 25 years: $5,400 + $8,215 + $5,125 = $18,740.

Conclusion: With a 30% tax incentive, the "payback" time of a net-metered system installed in 2006 in PNM's service territory is roughly 25 years (and about 40 years outside of PNM's territory).

Appendix C: Solar Hot Water System Example

System Assumptions:

- **Size of system:** One 30-40 ft^2 solar panel providing heat for one 80 gallon water tank.
- **Installed cost:** $4000.
- **System lifetime:** 25 years.

Conventional Hot Water Cost Assumptions:

- **DOE estimate of annual water heating costs with conventional gas water heater, assuming natural gas at $1/therm, 60% efficiency, and 60 gallons of usage per day:** $275/year.

- **DOE estimate of annual water heating costs with conventional electric water heater, assuming electricity cost of $.08/kWh, 90% efficiency, and 60 gallons of usage per day:** $430/year.

Value of a 30% Tax Incentive:

- Total installed system cost is $4,000.
- 30% of $4,000 = **$1,200.**

Comparison of Solar Heating Costs with Conventional over 25 years:

- Total Cost of Solar: $4000-$1200 = **$2,800**.
- Total Cost of Heating with Natural Gas: 25 yrs x $275 **= $6,875.**
- Total Cost of Heating with Electricity: 25 yrs x $430 **= $10,750.**

Payback Time of Solar Hot Water *without* a 30% incentive:

- Relevant to Heating with Natural Gas: **$4000/$6,875 x 25 yrs = 15 yrs**

Relevant to Heating with Electricity: **$4000/$10,750 x 25 yrs = 9.3 yrs**

Payback Time of Solar Hot Water *with* a 30% incentive:

- Relevant to Heating with Natural Gas: **$2,800/$6,875 x 25 yrs = 10 yrs**
- Relevant to Heating with Electricity: **$2,800/$10,750 x 25 yrs = 6.5 yrs**

Appendix D: Solar Tax Credits Summary

- Credit level: 30% of the installed cost of a photovoltaic, solar hot water, or solar hot air system, minus any applicable federal credits, up to $9000.
- Systems for heating hot tubs and swimming pools are not eligible
- Off-grid commercial or industrial PV systems are not eligible (such as systems located at oil wells).
- All agricultural PV systems at a farm or ranch are allowed (such as PV systems used for off-grid water pumping).
- Any New Mexico taxpayer is eligible for the credits.
- A taxpayer can carry over the credits up to 10 years if their New Mexico tax liability is not large enough to absorb the credits in the first year.
- Eligible systems will have to meet technical standards set by the Energy, Minerals, and Natural Resources Department, and certified by the Department. These standards will not be onerous, but will ensure that eligible systems use good equipment, and are installed properly. Having such quality control was an absolutely essential provision for getting this bill through the Legislature.
- Credits will be available for systems that are installed and purchased after January 1 of 2006, through 2015.The amount of credits that can be issued each year is limited to $ 3 million per year for Photovoltaics, and $ 2 million per year for solar thermal systems.