Jicarilla Apache Nation Utility Authority

Strategic Plan for Energy Efficiency and Renewable Energy Development

Prepared with Support From:

Jicarilla Apache Nation Utility Authority

and

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Notes

On Sources and Materials

The purpose of this Strategic Plan Report is to provide an introduction and in-depth analysis of the issues and opportunities, resources, and technologies of energy efficiency and renewable energy that have potential beneficial application for the people of the Jicarilla Apache Nation and surrounding communities. The Report seeks to draw on the best available information that existed at the time of writing, and where necessary, draws on new research to assess this potential.

This Strategic Planning Report was built from a wide range of sources including new research, analysis of existing data and reports, personal interviews, and third party reports. In some cases, third party sources are extensively quoted, as noted in the report. In some cases, minor changes for formatting and/or grammar are the only evident differences from the original.

The reader should make note of attribution of sources and ensure continued attribution to original sources.

On Contributors

This report was primarily compiled and authored by Karl R. Rábago, a member of Board of the Directors of the Jicarilla Apache Nation Utility Authority at the time of writing. However, the Report benefits from the support and contributions of many others. The people and organizations who must be recognized, among the many who supported the project, include Mike Hamman, Brian Yeoman, Darryl Vigil, Alberta Velarde, Jerry Dumas, Merl Elote, Robert Wells, the sitting and past members of the Board of Directors of the Jicarilla Apache Utility Authority and the Jicarilla Apache Legislative Council, and sitting and past Jicarilla Apache Nation Presidents. Additional support was provided by several Tribal Agency staff, the DEA engineering firm, and the NORA and Jemez Mountain Electric Cooperatives. Guidance and support were provided over the entire duration of the Project by Lizana Pierce and Vicky DeHerrera of the U.S. Department of Energy Tribal Energy Program. The author thanks each of these valuable contributors. The primary author assumes full responsibility for any errors.

Executive Summary

This study provides a strategic assessment of opportunities for maximizing the potential for electrical energy efficiency and renewable energy development by the Jicarilla Apache Nation. The report analyzes electricity use on the Jicarilla Apache Reservation in buildings. The report also assesses particular resources and technologies in detail, including energy efficiency, solar, wind, geothermal, biomass, and small hydropower. The closing sections set out the elements of a multi-year, multi-phase strategy for development of resources to the maximum benefit of the Nation.

Project Products and Accomplishments

This Report meets the objectives established for the Project as established in the Project Proposal documents. This report is the only product of the US DOE-funded portion of the overall project.

The Project was premised on the concept that a detailed analysis of the energy efficiency and renewable energy development opportunities on the Jicarilla Apache Nation Reservation would reveal opportunities for energy and economic development that would improve the quality, economics, and environmental impacts relating to the energy systems serving the people of the Nation. The project plan involved a specific path that began with a quick assessment of demand and supply opportunities funded by the Utility Authority. In the second phase of the project, which involved US DOE assistance, initial findings were shared with key stakeholders and feedback was obtained for guiding more detailed analysis and review. This more detailed analysis is represents the core of the work reflected in this report. This report incorporates that work into a plan that recommends specific actions, beginning with a comprehensive energy efficiency program, and followed by more detailed implementation planning for development of renewable energy resources.

Table of Contents

1 INTRODUCTION

The goal of this study is to provide a strategic assessment of opportunities for maximizing the potential for electrical energy efficiency and renewable energy development by the Jicarilla Apache Nation. This introductory section provides basic factual information for the Nation and the State of New Mexico, and recounts the preliminary assessment of infrastructure, resources and demand relating to electricity use on the reservation.

Sections that follow will address particular resources and technologies in greater detail. The closing sections set out the elements of a multi-year, multi-phase strategy for development of resources to the maximum benefit of the Nation.

1.1 Basic Facts and Information

1.1.1 Tribal demographics

Dulce, New Mexico is the home community of the Jicarilla Apache Nation and the home of most tribal members who live on the reservation. In January 2002, tribal enrollment was 3,403. Some 990 of those members (29.1%) lived off the reservation. According to the US Census for 2000, which typically undercounts tribal members, there were 2,755 people living on the Jicarilla Apache reservation. Of those, 2,475 were natives and 280 (10.2%) are two or more races or non-native. Dulce residents numbers 2,623, of which 245 (9.3%) were two or more races or non-native.

The Jicarilla Apache tribal age distribution is similar to other Native American tribes in New Mexico. The pattern shared by native New Mexico tribes is that native tribes illustrate an age structure more bottom-heavy with proportionately fewer older persons and more younger persons when compared to the age profile for all races in New Mexico. In fact, the Jicarilla Apache age distribution is even more bottom-heavy than that for all New Mexico natives. Health data suggests that a higher rate of deaths from auto accidents is the main contributing factor for this data.

1.1.2 Housing

Tribal members living on reservations face many issues not normally experienced in most of America’s cities and towns.

Because home ownership is often tied to indigenous land tenure traditions, tribal members face particular problems obtaining financing from private, non-Native sources. In other cases, the reservation might not have adequate supporting infrastructure for home building and development. A study of housing and income on the Jicarilla Apache reservation in 2000 revealed a stagnant housing market with little turnover and a population of which two-thirds were HUD income eligible—both indicators of an inadequate housing environment. The study further found that about half of Dulce residents reported annual household income between $15,000 and $35,000. Household income itself represents the combined income of several adults living together.

There appears to be a bimodal distribution of household incomes—leading to two basic patterns of household situation. One involves households minimally able to meet income and home ownership needs. The second represents even poorer households with no substantial income or reliable source of income.

1.1.3 Tribal labor

Employment is always an issue of concern on Native American reservations. The 2002 Labor Report for the Jicarilla Apache Nation prepared by the Nation's Integrated Resources Management and Planning Office (IRMP) reveals the following on the status of employment on the reservation:

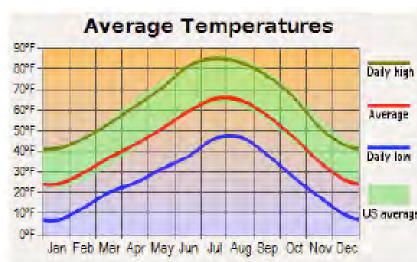
- The proportion of Jicarilla Apache tribal members living off the reservation has increased steadily over the past decade. In 2002, approximately 990 out of 3403 enrolled Jicarilla Apache tribal members (29.1%) were living off the reservation. This is an increased from 694 (20.9%) in 2000 and 450 (15%) in 1992-93.
- A significant number of young Jicarilla Apache members are enrolled in local schools. Of the 845 students enrolled in Dulce and Lumberton from Early Headstart to Grade 10, approximately 82% are Jicarilla Apache members, 9% are other Native Americans, and 9.3% are non-Native American.
- The Jicarilla Apache reservation-wide labor pool is made up of 68% Jicarilla Apache tribal members; 9% other Native Americans, and 23% non-Native American.
- The local labor market of 1496 jobs is approximately 75% full and part-time jobs, and 25% temporary or seasonal. Of the full and part-time jobs, about one-third (500 jobs)

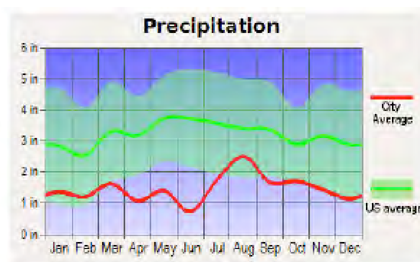
should be considered part-time because the positions average 3 days per week and often last less than one year.

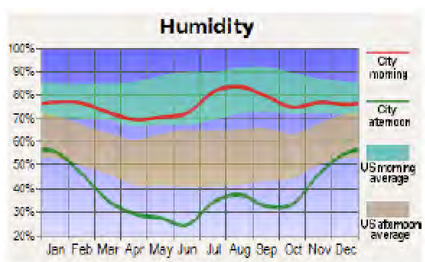
- Males fill 854 (57.1%) of the full and part-time jobs. The percentage is higher if temporary and seasonal positions are included.

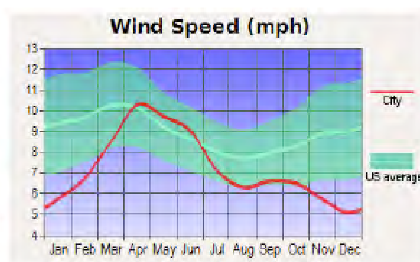
1.1.4 Local climate

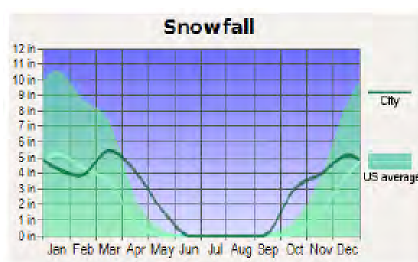
A few simple charts illustrate the average climate conditions in the Dulce and Jicarilla Apache Nation reservation area (Source: city-data.com). The Reservation and local region is characterized by a relatively dry, sub-alpine climatic regime. The area has plentiful sunshine with cooler than average temperatures and relatively light winds.

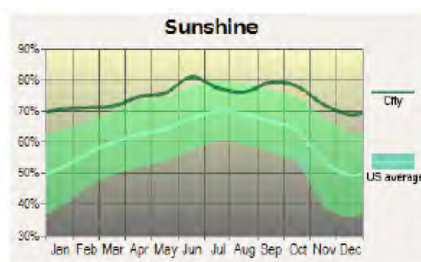


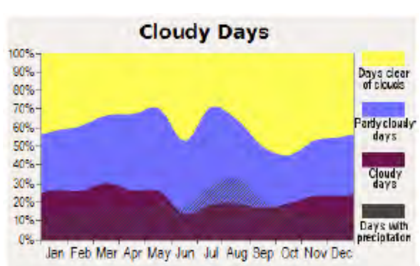












1.1.5 Electrical service to the Jicarilla Apache homeland

The Jicarilla Apache Reservation and annexed properties are served by two member-owned electric cooperatives. The northern end of the reservation, including the town of Dulce, is served by Northern Rio Arriba Electric Cooperative (NORA) headquartered in Chama. The central and southern portions of the reservation are served by Jemez Mountains Electric Cooperative (JMEC), headquartered in Espanola. The portion of the reservation served by NORA consists mainly of farms, residences, businesses and government buildings. The area within the reservation served by JMEC consists mainly of oil and gas wells with the associated compressor station loads.

Both coops obtain their power supply from the Tri-State Generation and Transmission Cooperative (Tri-State or TSGT) headquartered in Denver, Colorado. Tri-State owns and operates generating stations and transmission lines in the Rocky Mountain area from Wyoming to New Mexico, for the purpose of supplying electricity to distribution companies who then serve the end users.

NORA has a total of about 4,000 customers in the Chama area. The company's 2004 sales averaged 4.4 MW. Sales were evenly split between residential and commercial/industrial users. JMEC serves portions of San Juan, Rio Arriba, Sandoval, Los Alamos, McKinley, and San Miguel counties. At the end of 2004 the company had approximately 30,000 customers, primarily residential, with average sales of about 34 MW. Tri-State has 42 other member retail coops, operates 5,100 miles of high-voltage transmission lines, and has over 3,100 MW of generation capacity in its portfolio.

Table 1.1 lists NORA's current base rates, adopted as of July 2005. Additional fuel and optional services charges are not listed.

Table 1.1 - NORA Rates

NORA RATES – As of July 2005	
RESIDENTIAL – 4	
System Charge	$15.00
Energy Charge/kWh	0.0777
RESIDENTIAL TIME OF USE – 14	
System Charge	$15.00
Energy Charge/kWh ON Peak	0.11
Energy Charge/kWh OFF Peak	0.0385
SMALL COMMERCIAL SINGLE PHASE – 2	
System Charge	$22.00
Energy Charge/kWh	0.077
SMALL COMMERCIAL SINGLE PHASE TIME OF USE - 15	
System Charge	$25.00
Energy Charge/kWh ON Peak	0.11
Energy Charge/kWh OFF Peak	0.0385
SMALL COMMERCIAL POLY PHASE – 3	
System Charge	$30.00
Energy Charge/kWh	0.077
SMALL COMMERCIAL POLY PHASE TIME OF USE - 15	
System Charge	$25.00
Energy Charge/kWh ON Peak	0.11
Energy Charge/kWh OFF Peak	0.0385
LARGE COMMERCIAL - 5	
System Charge	$30.00
Energy Charge/kWh	0.031
Demand Charge	$14.50/KW
NORA Rates - Continued	
LARGE COMMERCIAL TIME OF USE - 16	
System Charge	$35.00
Energy Charge/kWh ON Peak	0.044
Energy Charge/kWh OFF Peak	0.02
Demand Charge ON Peak	$15.50/KW
Demand Charge OFF Peak	$ 0.00/KW
LIGHTING SERVICE	
100 watt HPS	$ 7.50
175 watt MV	$ 9.00
250 watt HPS	$10.70
400 watt MV	$14.75
DEBT COST ADJUSTMENT NOT ADDED TO KWH ENERGY CHARGE –	
ALSO ALL THE RATES HAVE A 4% FRANCHISE FEE FROM JAN	

1.2 The Broader Context - Energy Consumption in New Mexico

This plan focuses on renewable energy and energy efficiency for the Jicarilla Apache Nation. Many of the development and business opportunities presented here also have potential to support Jicarilla Apache-based businesses serving the broader northern New Mexico region. The state as a whole is home to some 2 million people, growing at a rate of about 1.2% per year. For that reason, a basic survey of energy facts for New Mexico as a whole is presented in the following tables and figures. Source: Southwest Energy Efficiency Project, www.swenergy.org

1.2.1 Statewide data

Table 1.2 - New Mexico Primary Energy Consumption & End Use, 2004 (with rankings in US)

Primary Energy Consumption	0.68 quadrillion Btus
Average Growth Rate, 1995-2004	1.2% per year
Primary Energy Consumption per Capita	359 million Btus
Ranking, Per Capita Consumption	21 of 51 (1 is highest)
Ranking, Total Consumption	38 (1 is highest)
End Use (%)	
Residential	15.7%
Commercial	17.8%
Industrial	33.4%
Transportation	33.2%
Energy Expenditures	$5.2 billion
Ranking, Energy Expenditures	38 (1 is highest)
Energy Expenditures Per Capita	$2,745
Ranking, Energy Expenditures Per Capita	37

Figure 1.1 – New Mexico Primary Energy Consumption (2004)

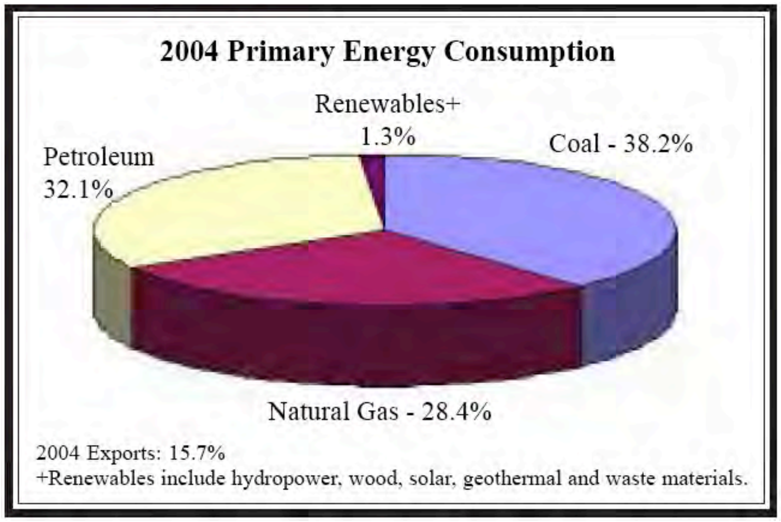


Table 1.3 – New Mexico Electricity Use, 2006 (with ranking in US)

Total Retail Sales	21.4 billion kWh
Ranking, Total Retail Sales	39
Avg. Consumption Growth Rate, 1997-2006	2.0%
Electricity Use Per Capita	10,966 kWh
Residential Electricity Use Per Household	7,068 kWh
Average Electricity Price, All Sectors	$0.0737/kWh
Ranking, Average Electricity Price	28

Figure 1.2 – New Mexico Electricity Generation, 2006

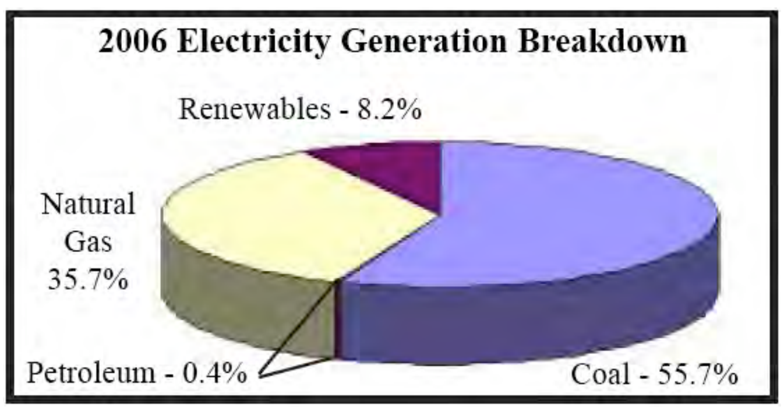


Figure 1.3 – New Mexico Electricity Detail, 2006

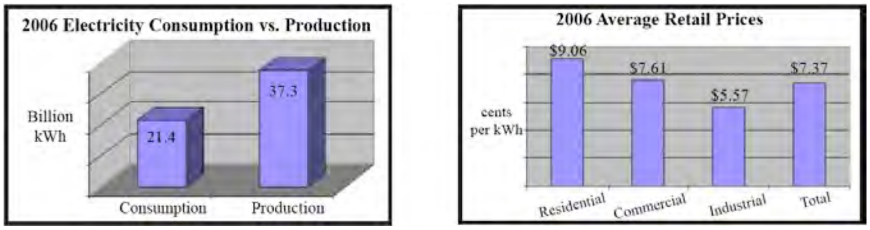


Table 1.4 - New Mexico Natural Gas Use, 2006

Total Consumption	224.1 Bcf
Ranking, Total Consumption, 2005	30
Consumption Growth Rate, 1997-2005	-2.3% per year
Natural Gas Use Per Capita	114,654 cubic feet
Residential Gas Use Per Household	35,799 cubic feet

Figure 1.4 – New Mexico Natural Gas Use by Sector, 2006

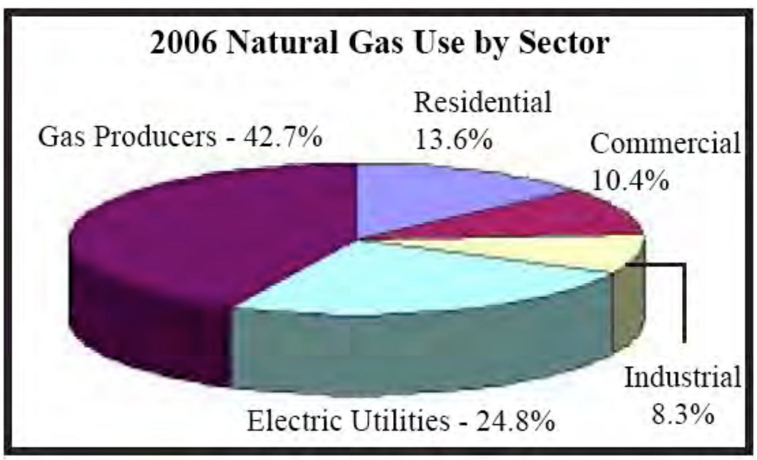
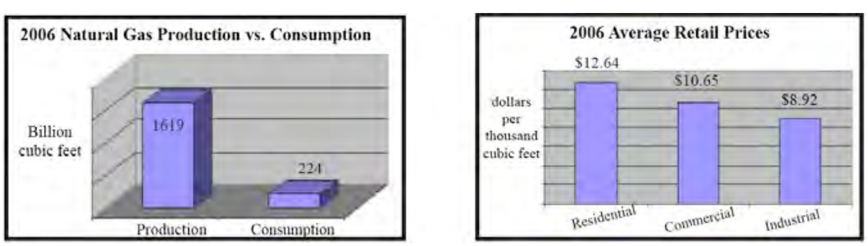


Figure 1.5 - New Mexico Natural Gas Use Detail, 2006



1.2.2 State energy efficiency goals

On November 16, 2007, New Mexico Governor Bill Richardson signed Executive Order 2007-053, setting goals of reducing energy use per capita in the state 10% below 2005 levels by 2012 and 20% below 2005 levels by 2020. The Order also directs state agencies to reduce their energy use 20% by 2015. Governor Richardson also announced his support for a number of legislative and budgetary initiatives to advance energy efficiency in the 2008 legislative session.

For details on the Executive Order, visit: http://www.swenergy.org/news/2007-11-EO_2007_053.pdf

1.2.3 Electricity demand-side management

Public Service Company of New Mexico, the state's main electric utility, began implementing electricity conservation programs in 2007. For details, visit http://www.pnm.com/rebates/home.htm. *Xcel Energy (Southwestern Public Service Company)* offers some energy conservation programs; to learn about residential programs, visit www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-2-2-6_523_943-0,00.html, and to learn about business programs, visit www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-3_19900-281-6_523_943-0,00.html. State legislation adopted in 2005 encourages additional utility energy efficiency programs.

Estimated spending of utility energy efficiency programs in 2005: $4 million

Energy efficiency spending as a fraction of utility revenues: 0.25%

1.2.4 Status of building energy codes

New Mexico adopted the 2006 version of the International Energy Conservation Code as a mandatory code for all new building construction. For more information, see SWEEP's study *Increasing Energy Efficiency in New Buildings in the Southwest: Energy Codes and Best Practices*, at www.swenergy.org/ieenb/index.html.

Figure 1.6 – Electricity Conservation Savings Potential

Electricity Conservation Potential and Impacts*

Savings potential in 2010: 19%
Savings potential in 2020: 36%
Avoided new power capacity: 2,400MW
Net dollar savings (2003-2020): $2.8B
Net increases in jobs by 2020: 6,900
Water savings by 2020: 7B gallons/yr

*Based on the High Efficiency Scenario in SWEEP's study *The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest*, at www.swenergy.org/nml/index.html.

1.2.5 Natural gas demand-side management

As of 2007, Public Service Company of New Mexico is the only utility in New Mexico operating natural gas conservation programs for its residential customers.

1.2.6 Climate change

In 2006, New Mexico Governor Bill Richardson established statewide goals to reduce New Mexico's future greenhouse gas (GHG) emissions to year 2000 levels by 2012, to 10% below 200 levels by year 2020, and to 75% below the 2000 level by year 2050. Key strategies to be employed include improving energy efficiency for buildings and appliances and reducing energy demand by consumers and businesses. For more details, visit: http://www.nmclimatechange.us/.

1.2.7 State energy efficiency scorecard

The American Council for an Energy-Efficient Economy (ACEEE) has ranked states based on scores in eight categories of energy efficiency commitment and policy support as of 2004. The categories include (1) spending on utility and public benefits energy efficiency programs, (2) energy efficiency resource standards (EERS), (3) combined heat and power (CHP), (4) building energy codes, (5) transportation policies, (6) appliance and equipment efficiency standards, (7) tax incentives, and (8) state lead by example and research & development. In this national ranking, New Mexico was 24th among all states with a score of 11 points out of a possible 44 points.

1.3 New Mexico Public Regulation Commission and Renewable Energy in New Mexico

(Source: New Mexico Public Regulatory Commission http://www.nmprc.state.nm.us/renewable.htm)

The Public Regulation Commission reviews and approves renewable energy procurement plans and reports of Investor Owned Utilities ("IOU's") and Rural Electric Cooperatives ("Coops") pursuant to the Renewable Energy Act ("REA"), §§ 62-16-1 et seq. NMSA 1978 and Title 17.9.572 NMAC ("Rule 572"). IOU's in New Mexico are procuring renewable energy and renewable energy certificates from New Mexico renewable generation facilities to meet the Renewable Portfolio Standard (RPS) requirements of the REA and Rule 572.

1.3.1 Investor owned utilities and the RPS

The REA and Rule 572 established an RPS applicable to all investor owned electric utilities in New Mexico. In 2006, the RPS will be 5% of retail sales in kWh's, reaching 10% by the year 2011. Recent legislative changes to the REA (SB418, signed March 5, 2007 by Governor Bill Richardson) have increased the RPS percentages and extended the time lines - IOU's now must have in their portfolio as a percentage of total retail sales to New Mexico customers, renewable energy of no less than 15% (by 2015) and 20% (by 2020).

1.3.2 Resource diversity and the RPS

In addition to the RPS, Rule 572 requires that IOU's must offer a voluntary renewable energy program to their customers. In addition to and within the total portfolio percentage requirements, utilities must design their public utility procurement plans to achieve a fully diversified renewable energy portfolio no later than January 1, 2011, as follows:

Diversity requirements for IOU's as % of total RPS requirement:

- No less than 20% Wind
- No less than 20% Solar
- No less than 10% Other technologies
- No less than 1.5% Distributed Generation (2011-2014) and 3% Distributed Generation by 2015

1.3.3 Reasonable cost threshold

A public utility shall not be required to add renewable energy to its electric energy supply portfolio, pursuant to the renewable portfolio standard, above the reasonable cost threshold established by the Commission. The reasonable cost threshold for 2006 is one percent of all customers' aggregated overall annual electric charges, increasing by one-fifth percent per year until January 1, 2011, at which time it will be two percent.

1.3.4 Rural electric cooperatives and the RPS

The recent changes to the REA also included expanding the RPS requirements to rural electric cooperatives. Renewable energy must comprise of no less than 5% of retail sales to New Mexico customers by 2015 and the RPS will increase at a rate of 1% annually until 2020, at which time the RPS will be 10%. In addition to the RPS, Rule 572 also requires that Coops must offer a voluntary renewable energy program to their customers provided their supplier makes renewable resources available.

1.3.5 RPS compliance

2006 is the first compliance year for New Mexico IOU's, meaning that IOU's must demonstrate they have met the RPS requirements in their Renewable Energy Portfolio Reports to the Public Regulation Commission. These reports must be filed with the Public Regulation Commission by September 1, 2007 and by July 1 of each year thereafter.

1.3.6 Renewable energy certificate tracking

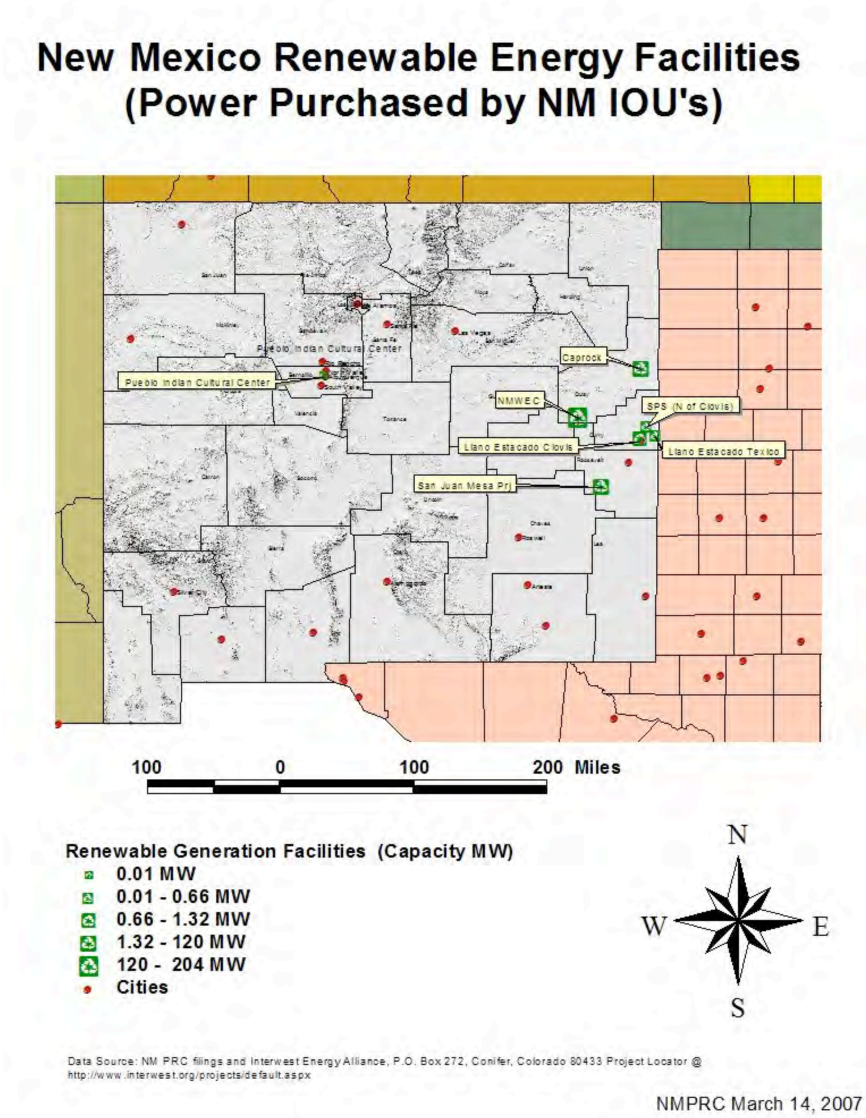
The acquisition, sale or transfer, and retirement of any renewable energy certificates used to meet renewable portfolio standards on or after January 1, 2008 must be registered with the Western Renewable Energy Generation Information System (WREGIS). WREGIS is the Western Governors' Association's independent regional tracking system to provide data necessary to substantiate and support verification and tracking of renewable energy generation.

1.3.7 Annual renewable energy portfolio procurement plans

Public utilities (IOU's) must file with the Commission an annual portfolio procurement plan on September 1, 2007, July 1, 2008 and July 1 of each year thereafter. Rural Electric Distribution Cooperatives must file with the Commission by March 1 of each year, a report on its purchases and generation of renewable energy during the preceding calendar year. Rural Electric Distribution Cooperatives must also report to their membership a summary of their purchases and generation of renewable energy during the preceding calendar year. Renewable energy plans and reports that public utilities file with the Public Regulation Commission are also required to be made available on the utility's website.

1.3.8 Renewable energy capacity in New Mexico

New Mexico has several utility scale renewable generation facilities.



1.3.9 Other renewable energy programs

While IOU's are complying with the RPS through primarily power purchases from non-utility or independent power producers ("IPP's"), there are other programs that purchase REC's from customer sited photovoltaic installations of 10kW or less. One such program is PNM's Small PV Program.

1.3.10 Voluntary (green power) programs

1.3.10.1 Investor owned utilities

As required by Rule 572, investor-owned utilities (IOU) must offer a voluntary renewable energy program to their customers. New

Mexico's three IOU programs offer blocks of renewable energy sales in 100 kWh increments. El Paso Electric charges $3.19 per 100 kWh block of its wind and solar based Renewable Energy Program offering. Public Service Company of New Mexico's "Sky Blue" program sells wind energy blocks for $1.80 per 100 kWh. And Southwestern Public Service sells 100 kWh blocks of its wind based "Windsource" product for $3.00, minus any fuel cost savings from not consuming fossil fuels.

1.3.10.2 Rural electric cooperatives

As required by Rule 572, Coops must offer a voluntary renewable program to their customers to the extent that their energy suppliers make such renewable resources available. Currently Tri-State Generation & Transmission supplies energy to most New Mexico Coops, as well as green power for the Coops voluntary programs. Current rates for green power sold through Tri-State's Renewable Energy Program are $1.25 per 100 kWh block.

1.4 Electrical Energy Infrastructure Assessment

1.4.1 Electrical transmission

There are very few miles of transmission-class (69 kV and higher) power lines inside the reservation. (Figure 1.7).

NORA and Tri-State are currently studying alternatives to reinforce the supply to the area, including ways to supply power to the Dulce substation. (Figure 1.8). The choice of which alternative to implement will be greatly influenced by the Nation's plans for future load growth, industrial development, or energy export.

The central and southern end of the reservation is served by JMEC. The JMEC system consists of 69 kV lines feeding several substations near the southern border of the reservation, with 24.9 kV feeders to the loads. According to JMEC, this system is fully utilized with little to no capacity to carry additional load. The coop has also been discussing system improvement alternatives with Tri-State. The Nation's plans for increased electrical load or electricity export will influence other system improvement efforts.

The two cooperatives supplying electric power in the reservation get their power supply from Tri-State, through 115 kV connections to the coops east and south of the reservation at the Ojo, Hernandez, and La Jara substations. These substations are a part of the southern Rocky Mountain grid which consists of high-capacity transmission lines operated by Tri-State, Western Area Power Authority (WAPA), and other utilities. The 115 kV lines supplying

JMEC and NORA are the La Jara- San Ysidro, Ojo-Taos, and Hernandez-Taos lines. Caution should be used as the available transmission capacity may be quite different than the line ratings shown on the spreadsheet. Tri-State would have to evaluate the available energy carrying capacity of the lines under specific circumstances.

Public Service New Mexico (PNM), the investor-owned utility serving some of the surrounding areas, owns and operates a 345 kV transmission line that traverses the southern end of the reservation. This line connects to Tri-State east of the reservation but does not directly connect to the coops in the area. One of the system improvement alternatives shown in Figure 2 would involve a new connection between Tri-State, JMEC and PNM.

1.4.2 Electrical infrastructure description

1.4.2.1 Substations

The only substation within the reservation is JMEC's Tancosa substation at the extreme southern end of the reservation near the Apache Nugget casino (Teepee corner). Tancosa is connected to the La Jara substation just outside the reservation, which is also connected to Tri-State at 115 kV. The 69 kV line from La Jara to Tancosa continues on to supply the Lybrook Substation at Lybrook west of the reservation. All three substations supply gas and oil well load both inside and outside the reservation.

NORA's Chama substation that feeds the Dulce area is 25 miles from Dulce. The single supply to the substation is the 69 kV line from Tri-State, at Coyote Junction. The substation appears to have four outgoing feeders at 14.4 / 24.9 kV. The transformer is relatively new (about 2 years) and rated at 7.5 MVA. In general, the substations that were observed appear to be in good condition and well maintained.

Figure 1.7 – Regional Transmission System Map

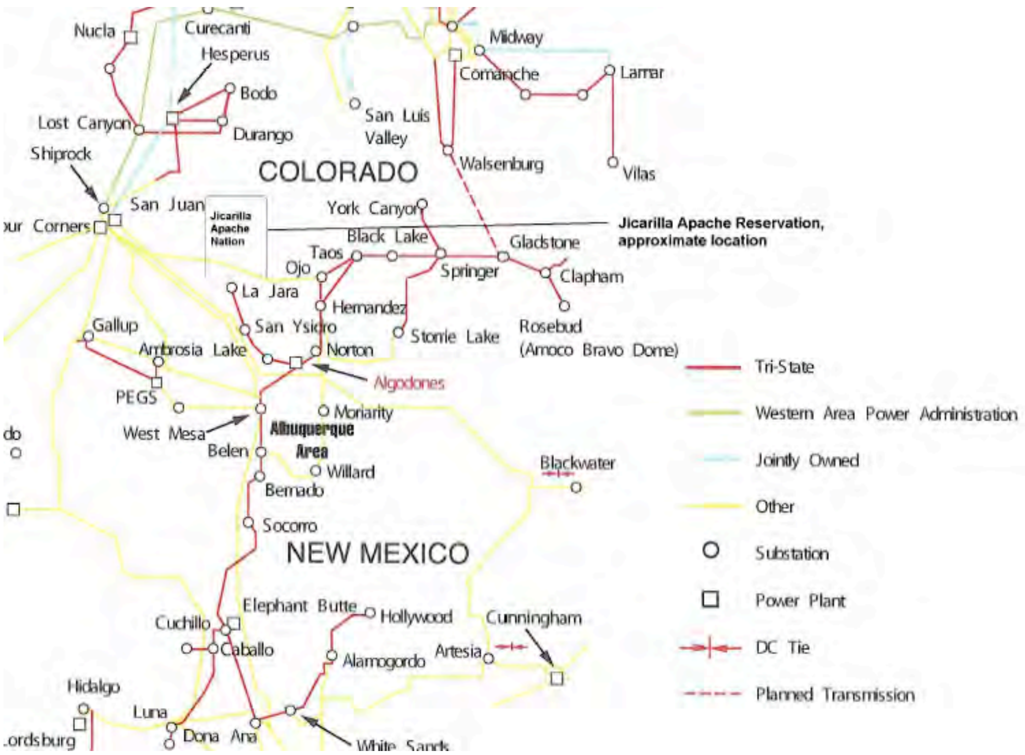
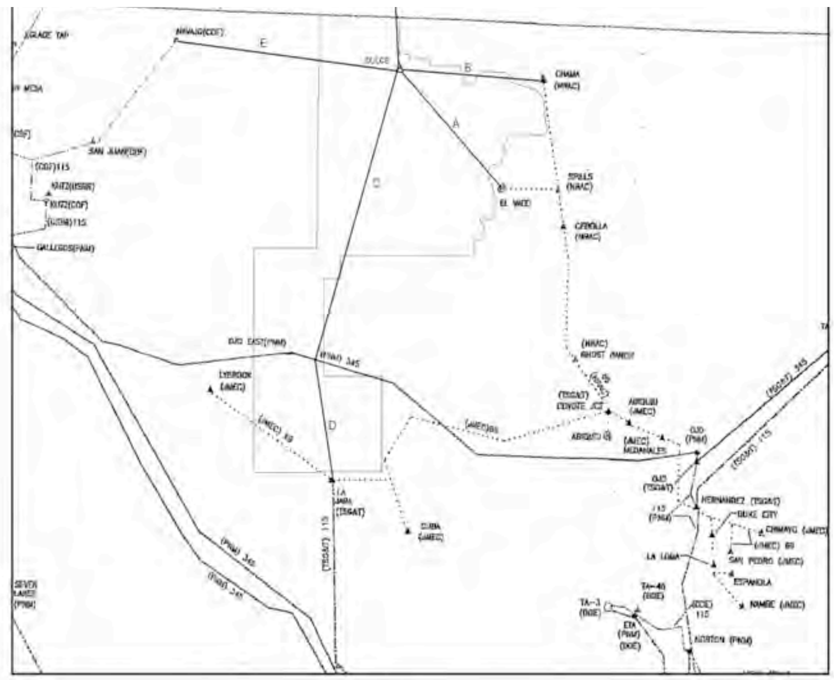


Figure 1.8 - Possible Transmission and Distribution Improvements



KEY

Dulce a new substation in Dulce south of Highway 64 across from the Conoco station.
A a new tie from El Vado substation to Dulce.
B a new or reinforced tie parallel to the existing feeder from NORA's Chama substation to Dulce. If this option is used, one or more of the other options would also be advisable.
C and D a new tie from La Jara substation (JMEC and Tri-state) to a new tap on PNM's 345 kV line, and on to the new Dulce substation.
E a new tie to the west with [Continental Divide Electric Coop].
F a new tie to the north with Tri-State.

Figure 2
Possible Transmission and Distribution Improvements

Scale - Not to Scale

1.4.2.2 Distribution

Both of the coops serving the reservation operate on a 14.4 / 24.9 kV system. The populated northern end of the reservation, including the town of Dulce, is fed by a single 25 mile long 24.9 kV distribution line from NORA's Chama substation in south Chama. This feeder and the Chama substation are in good condition, but accounts of power quality problems may indicate a weakness in some part of the system. Anecdotal evidence of phase imbalance, outages and voltage sags indicate the borderline adequacy of the supply. This may be a consequence of the fact that Dulce is 25 miles from the Chama substation, and therefore vulnerable to the losses and disturbances that naturally occur on the long distribution line feeding the area.

Plans to improve the quality of the feed to Dulce could range from building a new feeder from a different source to adding voltage regulators or capacitors near Dulce. A new feeder as shown on Figure 2 would have several benefits, such as: reducing the dependence on a single line for power supply; making power more accessible in parts of the reservation that currently do not have a convenient power supply; and making the power supply in Dulce more robust.

1.4.2.3 Condition assessment

Major utility equipment such as poles, wire, insulators, and transformers should have an economic life of 50 years, with a range between 30 and 80 years. The equipment feeding the Dulce area, including the transformer at the Chama substation and the 24.9 kV feeder from Chama to Dulce, are relatively new and appear to be in good condition. The 69 kv / 25 kV transformer in the Chama substation is nearly new. These assets will probably be outgrown before they are in need of replacement due to age.

1.5 Preliminary Resource Assessment

The following sections discuss various alternative energy system types and sizes. For comparison, the average Dulce residential customer consumes about 5.5 MWh (5,500 kWh) of electricity a year which is equivalent to 0.62 average kW. The estimated annual energy consumption of the town of Dulce is about 13,000 MWh (13,000,000 kWh) per year or 1.5 average MW (1,500 average kW).

1.5.1 Solar photovoltaic

The Tribe installed a 2.4 kW photovoltaic (PV) panel array on the roof of the high school in August 2000. The final report for the project noted a project cost of about $35,000 with an annual energy savings of about $250. The calculated capacity factor was approximately 15 percent. The tribe also operates several PV-powered well pumps providing stock water in remote areas.

The BIA has supplied a draft 2002 report containing summaries of data collected from solar radiation sensors on the reservation from 1986 to 1994. The data includes limited meteorological data at a couple of sites. Detailed data is available in MS Excel format.

Although photovoltaic power systems are not currently competitive with other generation technologies where grid-connected power is available, this will probably change in the future as hardware costs drop. According to the International Solar Energy Society, the rapidly increasing PV panel production rate and improving conversion efficiencies contribute to hopes that solar PV energy costs will be economical as early as 2010.

1.5.1.1 Small solar energy systems

Grid-Tied

When vendors use the term 'grid-tied,' they are referring to a system that supplies a load that is also served by the electric grid. Such a system will have solar panels, controllers, and an inverter to convert the low voltage DC output of the solar panels to 120v AC for domestic use. These systems do not include batteries because they assume that power will come from the grid when home use exceeds solar panel output. When solar panel output exceeds home use, the energy will either go unused or be fed back into the grid.

Off-Grid

'Off-grid' systems will include solar panels, a controller, an inverter, and a bank of batteries. When home use exceeds the solar panel output, energy will be drawn from the batteries. When solar panel output exceeds home use, the batteries will be charged. The costs of off-grid systems below include a proportionally sized bank of batteries.

Table 1.5 - Typical Grid-Tied Solar Systems

Make or Vendor	Rating	Approximate annual energy at 15% capacity factor	Estimated cost including installation
Energy Outfitters	2.8 kW	3,650 kWh	$22,500
Kyocera	3.0 kW	4,000 kWh	$21,000
SunWize	3.0 kW	4,000 kWh	$29,000
SPS	3.0 kW	4,000 kWh	$24,000
Sun Power & Geothermal*	1,060 kW	1,400,000 kWh	$7,400,000
* actual system installed at Butte Community College			

Table 1.6 - Typical Off-Grid Solar Systems, Battery Backup Only

Make or Vendor	Rating	Approximate annual energy at 15% capacity factor	Estimated cost including installation
AAA Solar	0.2 kW	260 kWh	$12,000
Affordable Solar	1.3 kW	1,700 kWh	$15,000
Affordable Solar	3.1 kW	4,000 kWh	$30,000

System sizing

As can be seen in the above table, a $30,000 domestic solar energy system could supply the needs of an energy-efficient and carefully managed home. Domestic energy consumption can be reduced considerably through the elimination of electric heating and air conditioning and through the use of specialized appliances such as efficient DC powered refrigerators and freezers. Although more costly, these appliances will enable a modest home to be run by a battery-backed solar system with few sacrifices.

Grid-tied systems can be sized at whatever capacity is desired or economical. Because under-generation will be made up by grid power and over-generation can be fed back to the grid, there is no impact to the home occupant for over or under-sizing other than economic impact. The economic impact depends greatly upon whether the utility will compensate the homeowner for the excess energy.

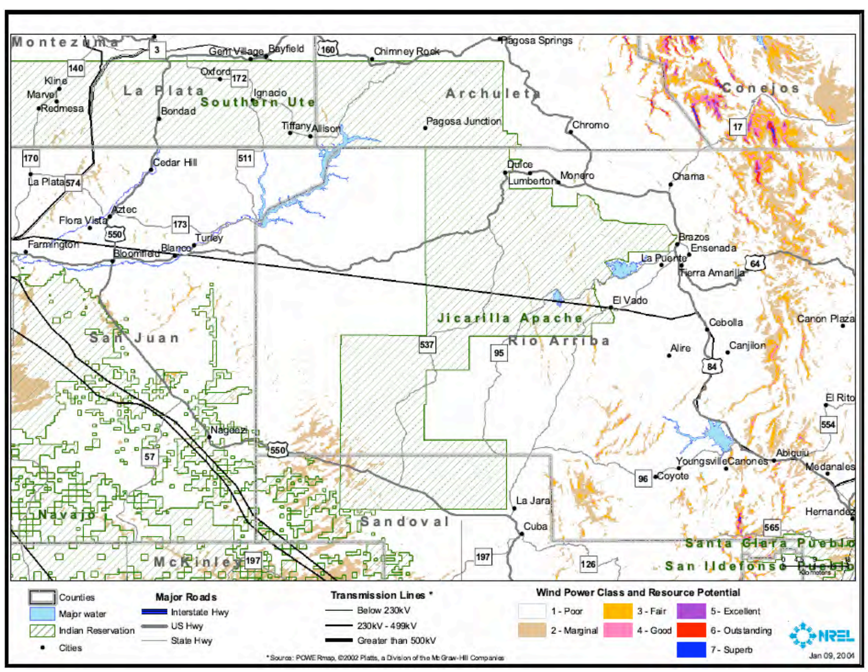
Off-grid system sizing is critical, because the electric power supply will be interrupted when the batteries are drawn down. A system supplier will help a homeowner size a system, including a backup prime power supply that can automatically take over when the battery charge level declines to a certain point. Backup power supplies are typically provided in the form of an engine-driven generator and will add 10% to 20% to the cost of the system.

1.5.2 Wind

There are no existing wind power projects on the reservation, and no monitoring has been performed for the purposes of gauging wind power. Computer-generated wind resource maps do not show much potential in the area except on ridge lines. The wide open terrain and anecdotal accounts of wind in the southern portion of the reservation may justify the deployment of a 20 or 30 meter anemometer for informational purposes.

Figure 1.9 is a map of the estimated wind resource quality in the reservation and surrounding area. The authors used the “First Look” wind resource estimation tool to obtain detailed wind data for the most promising location for large scale wind generation, in the southern part of the reservation. The site features both ridge line geography and proximity to transmission facilities and load centers. The analysis conducted by the First Look study revealed a relatively poor resource, confirming the high-level data available from the resource map.

Figure 1.9 – Wind Resource Map with Transmission Data



The National Renewable Energy Laboratory (NREL) and Western Area Power Administration (WAPA) operate an anemometer loan program. They suggest that tribes that do not have wind resources well characterized should apply for the 20-meter anemometer before pursuing tall tower anemometers. Erection of the 20-meter tower does not require any special expertise or construction work. As a result, the investment required to collect potentially valuable wind information is mainly in time spent to periodically check the tower and collect data. Using loaned equipment means that the collected data will be made public. The Tribe could buy a tower and metering equipment for about $5-10,000 if data privacy is necessary.

1.5.2.1 Small wind power systems

Similarly to solar systems, wind energy systems can also be configured to be grid-tied or off-grid. However, the less-dependable nature of wind power means an off-grid system is almost always configured with a backup power supply. Extended periods of low or no wind will cause batteries to be drawn down and an alternate source of energy, such as an engine-driven generator, or batteries, will be needed.

Wind energy systems are also more dependent upon the location. Some areas are not 'windy' enough to justify a wind-powered generator, whereas almost any location with a clear view of the sky will be suitable for solar system installation. On the Jicarilla Apache reservation, exposed locations in the southwest corner of the reservation should yield marginal to good wind quality. In the rest of the reservation, one would have to find unique topographic features such as broad ridge tops or saddles that concentrate winds.

The energy production of any wind energy system can be enhanced by locating the turbine on the highest tower practical. This is due to the fact that wind speeds increase with elevation above the ground and wind turbine output increases greatly with relatively small increases in wind speed. Generally, the slightly additional cost of a taller tower will be offset by increased production from the wind turbine. Tower kits of 100 to 120 feet are available to make the most of the system. The cost of a tall tower is included in the system costs below.

Because of the lack of high wind areas in or near the reservation, the Tribe should consider purchasing turbines optimized for low-wind locations. These wind turbines will generally have longer blades and will be made to 'cut in', or begin generating, at lower wind speeds than the standard models.

Table 1.7 - Typical Small Wind Systems

Make or Vendor	Rating	Capacity factor	Approximate annual energy	Estimated cost including installation	$/kw
Whisper*	3.2 kW	0.11	3,100 kWh	$20,000	$6,250
Bergey*	7.5 kW	0.11	7,200 kWh	$47,000	$6,270
Bergey	10 kW	0.11	9,600 kWh	$53,000	$5,300
Jacobs	20 kW	0.11	19,300 kWh	$70,500	$3,525
AOC	50 kW	0.11	65,700 kWh	$135,000	$2,700
GE**	1500 kW	0.25	3,285,000 kWh	$2,500,000	$1,700
* Suitable for off-grid battery charging **Large machine for reference purposes					

Used wind turbines

Large wind turbine technology has progressed in the past 20 years. Whereas large wind turbines used to be 100 to 250 kW, they are currently being manufactured in the 1,500 to 2,500 kW range. Rather than continue maintenance of older wind turbines, owners of older wind turbine farms are finding that it is more economical to replace their older wind turbines with the new, larger models because of the larger models' increased energy output and capacity factor. A single 2,000 kW wind turbine will produce far more energy in kWhs than ten 200 kW turbines as explained below. Therefore, many fully functional refurbished wind turbines are available for purchase. Should the Nation want to investigate a wind power system to augment power for residential or commercial development, the used wind turbine option should be investigated. Details are not provided herein because prices vary with availability and some engineering is required to estimate relocation and tower costs.

Large vs. small wind turbines

Wind turbine systems benefit from the economies of scale, as can be seen in Table 1.7. Large turbines have additional advantages because they have better capacity factors and access to higher quality wind. Their capacity factors are higher because their variable pitch blades allow optimal efficiency over a range of wind speeds rather than at just one wind speed (like a smaller turbine with fixed-pitch blades). These turbines access higher quality wind because they are positioned at higher elevations above the ground, which takes advantage of higher and more consistent winds. A megawatt class wind turbine could have twice the capacity factor of a small wind turbine at the same location. Of course, the significantly higher costs to build a large wind farm means that large project scale is required to compete with more cost effective sites. Large sites also entail more expensive site preparation, more expensive installation equipment, and other costs.

1.5.3 Biomass

Energy production using a biomass-fueled boiler or gasifer would depend upon a large and economical fuel supply. Ideal sources would be mill-ends and sawdust from mills, slash from timber harvest operations, large-crop agricultural by-products, and waste from thinning and forest clean-up operations. The lack of any significant municipal solid waste or agricultural by-products in the reservation area indicates forest waste as the only likely biomass fuel.

40 to 60 tons of wood fuel would have to be economically transported to a biomass boiler each day for each megawatt of generator size.

The proposed Jicarilla Lumber Mill project could be a source of wood waste for pelletization or gasifier use. Wood waste from thinning operations in the Jicarilla Apache Nation-managed forests appears to be insufficient to supply a biomass generator because of the acreage involved. The IRMP references a limit of 8 million board feet per year harvest rate, which equates to about 4,000 acres per year. Theoretically, three to five megawatts could be generated from harvest by-products and waste such as tree limbs. (This is assuming that a high percentage of that waste could be gathered and transported to a boiler.) Biomass boilers are usually located at lumber processing mills so higher-quality and less expensive fuels such as mill waste, bark and sawdust could be used in the boiler with nominal transportation costs.

However, actual harvest rates on the reservation have been lower due to the lack of market interest. Gathering and transportation costs have historically been prohibitive when harvest byproducts or thinning products have been the sole fuel source. A pelletization plant may offer a viable economical complement to an otherwise non-cost effective timber mill.

1.5.4 Hydroelectric

The Department of Energy's Energy Efficiency and Renewable Energy division (EERE) and the Idaho National Engineering Laboratory inventoried many potential hydroelectric sites, several of which appear to be within the reservation. Further study of these two inventories may lead to 'rediscovery' of an opportunity.

The Tribe may note a potential restriction on development of sites that involve water supplied by the San Juan-Chama Project, a participating project of the Colorado River Storage Project. In an Order Dismissing Preliminary Permit Application issued August 19, 1997 on Project No. 10979, the Federal Energy Regulatory Commission noted that Section 2 of the Colorado River Storage Project Act effectively prohibits hydropower development within that project. However, that restriction may not apply to the Tribe in light of the 1992 Jicarilla Apache Tribe Water Rights Settlement Act. Several of the inventoried projects appear to be within the San Juan-Chama Project.

The location of Project No. 10979 was Heron Dam. The Tribe commissioned a study on the hydroelectric generation potential at Heron Dam. According to a summary of the study by the EERE's Tribal Energy Program, the original idea was quickly determined infeasible and the scope of the study was widened to include other potential hydroelectric generation sites. The study currently resides in the Department of Energy’s archives.

The San Juan-Chama Project provides an additional 110,000 acre feet of water to the Rio Grande Basin, which delivers water to urban centers (including Santa Fe and Albuquerque) as well as to irrigation districts. The feat is accomplished by diverting water in Colorado from several upper San Juan River tributaries via the Azotea Tunnel through the Continental Divide to the Rio Grande Basin. The Azotea Tunnel discharges into Willow Creek within Jicarilla Apache annexed land.

Long-term stream flow and topography are essential data for a hydroelectric resource assessment. The tribe's GIS system and USGS topographic maps would provide reasonably accurate topography for screening purposes. Some stream flow data is available from the New Mexico Office of the State Engineer, the U.S. Geological Survey and the U.S. Bureau of Reclamation - Albuquerque Area Office of Water Operations. The Navajo River - Dulce Lake pipeline study also provides some stream flow and topographic data for the Navajo River.

Hydroelectric power generation is possible almost anywhere that a sufficient volume of water drops to a lower elevation, and where development is not prohibited by regulation. In order to gather and transport that water to a lower elevation with a minimal loss of potential energy, infrastructure such as intakes, flumes and pipelines has to be built. The cost of those facilities depends almost entirely upon the specific site characteristics and volume of water to be handled. These studies must be done on a case-by-case basis as possible generation sites are identified. For the Tribe's reference, the following table shows the approximate kW capacity of a hydroelectric facility with various flow and head (e.g., elevation drop) characteristics.

Table 1.8 – Power Output as a Function of Head and Flow

Head, ft	**Water flow, cubic ft/second**				
	0.2	**0.5**	**1**	**5**	**10**
25	0.30 kW	0.74 kW	1.5 kW	7.4 kW	14.8 kW
50	0.60 kW	1.5 kW	3.0 kW	14.8 kW	29.6 kW
100	1.2 kW	3.0 kW	5.9 kW	29.6 kW	59.0 kW
200	2.4 kW	5.9 kW	11.8 kW	59.0 kW	118.0 kW

Turbine and generator sets are available in the sizes listed in Table 1.8, ranging from $800 for a 300 watt (0.3 kW) machine to

$135,000 for a 100 kW machine. Larger machines are available on a custom-fabrication basis. The civil works necessary to deliver the water under pressure to the machine could be costly and are impossible to estimate without knowing the site characteristics.

1.5.5 Geothermal

The reservation may have some potential to yield geothermally heated water due to its proximity to the known geothermal areas of Chromo to the north, Los Alamos to the south, and Ojo Caliente to the east. However, little hard data has been found that supports the development of this resource on tribal land.

Chapter 5 addresses known geothermal resource quality in the reservation and surrounding area. Please note that the high-voltage transmission line shown going east-west through El Vado actually crosses the reservation much further south.

There is some anecdotal evidence of warm spring water existing close to the surface in the Mundo Ranch and Willow Springs ranch areas. If located, these could be explored for possible home or business heating, or aquaculture.

There is no evidence of any geothermally heated aquifer of the size and temperature necessary for energy generation. Down-hole temperatures encountered in oil and gas wells approach 180 degrees F,which is insufficient for power conversion.

It takes about 500 gpm of 290 degree F water to produce one megawatt of electric power. Water temperature below 260 degrees F is generally considered insufficient for power generation using conventional technology.

A report written in the mid-90's mentions a further geothermal investigation of the reservation planned by the Tribe. The 1999 IRMP states that a geothermal assessment was funded by an ANA grant. No data has been located.

Geothermal energy oriented consultants could conduct the specialized investigations necessary to further quantify the reservation's geothermal resources. A study to characterize the geothermal resources would be fairly expensive—costing $300,000 or more.

1.5.6 Fossil fuels

Natural gas, coal and crude oil resources on the reservation are extensive, widespread, and well documented. Detailed inventories and analyses of these resources have recently been completed for the Nation, though the report is not yet available. An isolated gas well about 2.5 miles southwest of Dulce is of particular interest for potential power supply in the Dulce area.

The well near Dulce is not piped into the existing gas system because of its high heat content (1,150 Btu/CF) and relatively remote location. Its estimated production rate is 150 to 200 mcf/day. A gas turbine or reciprocating engine fueled by this well could supply power to the northern end of the reservation. If located at the west end of Dulce, co-generated heat from a thermal power plant could be used at the wastewater treatment plant and the municipal building.

Supplying energy to the Dulce area would reduce the load on the feeder from Chama and provide voltage support, thereby improving power quality. The production rate and heat content of the well as estimated by JAECO would yield about 1/2 megawatt of electricity.

1.6 Preliminary Demand Assessment

1.6.1 Current energy demands for the reservation, with different areas of the reservation described for energy planning purposes.

The reservation has two distinct areas with differing energy demand characteristics. With small exceptions, the northern area surrounding the town of Dulce is characterized by residential and commercial loads, while the southern and central areas are characterized by oil and gas well loads and the associated industrial infrastructure.

Based on data furnished to the Western Area Power Authority in an April 2000 application for power allocation, the total average energy demand on the reservation between April 1998 and March 1999 was about 1.3 MW, of which about 1.23 MW was furnished by NORA and 0.8 MW was furnished by JMEC. Peak demand is about 5 MW total.

Of the NORA customers, the residential class represented about 40% of the energy use, small commercial about 15%, and large commercial about 45%. Of the JMEC customers, the residential class represented about 8% of the energy use, small commercial about 37%, and large commercial about 55%. Year over year, these proportions remain relatively steady.

1.7 Demand Forecast

1.7.1 Future demand

The area within the reservation served by NORA is governmental, commercial and residential. Anticipated load growth would be closely linked to population growth and economic conditions. Any significant increase of load in the northern part of the region would necessitate improvements to transmission and/or the development of local generation.

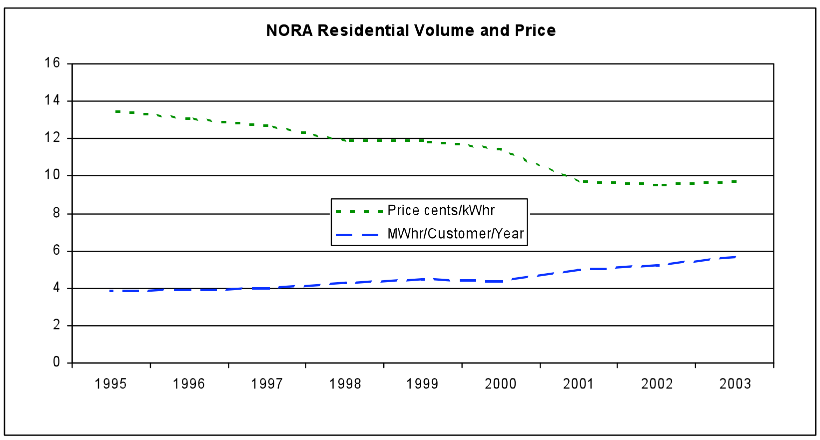
The existing area within the reservation served by JMEC contains oil and gas wells and compression station load. Timing of system improvements would be dictated by the rate of new oil and gas well drilling, the effect of commodity prices on pumping activity, and the possible construction of new major loads, like a compression station, in the area.

Using historical demand as a basis for forecasting future demand is problematic for a couple of reasons. The Tribe embarked on a governmental and municipal building program in the last couple of years that likely affected demand in Dulce. Demand throughout the reservation was also likely affected by high electricity prices in the late 1990's. During that period rates were about 50 percent higher than present partly due to the financial troubles of the wholesale supplier. Indeed, as prices fell from 1995 to 2001, residential demand increased three to five percent per year. Finally, gas and oil field activity has increased recently due to high commodity prices, influencing demand in the southern portion of the reservation. This fluctuation in demand is somewhat cyclical, following cycles in commodity prices.

According to the Jicarilla Demographic Study by IRMP in 2002, the medium case population growth rate for the town of Dulce from 2000 to 2020 is forecast to be 1.15% annually. Information extracted from the Energy Information Administration (EIA) Electric Sales and Revenue reports shows that the growth rate in energy consumption per NORA residential customer from 1998 to 2003 was about 5.5% annually. Compounding the two growth rates yields a 6.7% annual energy use growth rate for the residential class in Dulce. This growth rate should be used with caution however, since the increases in energy use per customer will eventually level off as households become 'saturated' with modern conveniences, or if energy prices rise and cause users to increase their conservation efforts. The 1998 through 2003 time period saw a decrease in NORA residential rates, which may have fueled some of the increase in consumption as shown in Figure 1.10, below. This further indicates that the 6.7% future growth rate is probably a high end estimate. Figures 1.10 and 1.11 chart the historical NORA rates and conventional assumptions of load and demand growth.

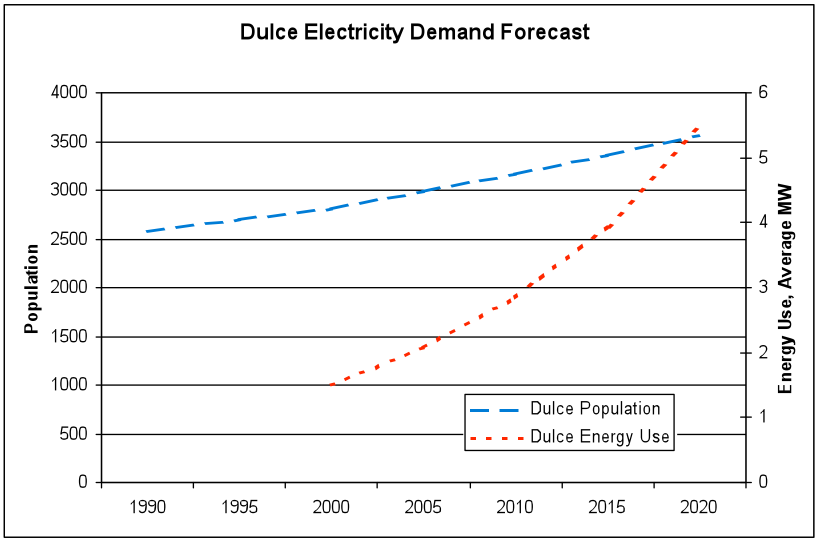
In sum, while years of high growth (5% or more) in demand are possible over the forecast period, the average growth rate is more modest. Such load growth can be meaningfully addressed through the planned introduction of efficiency, local generation, and improvements to local grid operations.

Figure 1.10 - NORA Residential Volume and Price



Assuming the predicted growth rate as described above holds true through 2020, Dulce area energy demand would reach about 5.4 average MW from an estimated 1.5 MW in 2000.

Figure 1.11 - Dulce Electricity Demand Forecast



1.7.1.1 Evaluation of potential large-scale supply and distribution gaps

There should be no major supply gap under any conceivable demand scenario on the reservation. The cooperative utilities supplying energy to the reservation are directly connected at high voltage in three locations to a grid with an available capacity of tens of thousands of megawatts. If the reservation's energy demands triple or quadruple, it could be fully accommodated by the regional grid. Any gap in service would come from the lack of new or improved distribution lines into the areas of the reservation of energy demand growth. Distribution system improvements can usually be made within a couple of years of a possible need being identified. Clear plans and schedules for systems improvements need to be developed with the two distribution cooperatives. Longer planning schedules are required if new transmission or distribution lines are required in new corridors, as right-of-way acquisition and/or environmental analysis often require longer lead-times.

2 Energy Efficiency

2.1 Introduction

Improving energy efficiency means reducing the amount of energy used for necessary energy services—heating, lighting, cooling, refrigeration, transport, etc. It is about using more efficient appliances, compact fluorescent lamps instead of incandescent lamps, better insulated buildings, more efficient windows, high efficiency air conditioning equipment, higher MPG vehicles, more efficient industrial processes, and the like. It is also about changing behavior—performing regular maintenance, reprogramming and adjusting thermostats, changing filters, turning off unnecessary appliances and lights, etc.—where possible. Improving energy efficiency is a “win-win” strategy—it saves consumers and businesses money, it reduces the need for costly and controversial new power plants and transmission lines, it increases the reliability of the energy supply, it cuts pollution emissions at power plants and at home, and it lowers energy imports. There is vast potential for improving the energy efficiency of homes, appliances, businesses, and vehicles in New Mexico. [Source: Southwest Energy Efficiency Project, www.swenergy.org]

2.1.1 The built infrastructure of the Jicarilla Apache Nation

The vicinity of Dulce, New Mexico, homeland of the Jicarilla Apache Nation, contains more than 1476 structures. About 441 of these residential structures were built by The Department of Housing and Urban Development (HUD). The age distribution of these (HUD) built structures is heavily weighted to the more than 20 years of age category (68.02% or 300 units), and of that, 45 are more than 30 years of age. There are 300 mobile homes throughout the reservation, with more than 100 of these units built before 1994. Additionally, Jicarilla Construction has built 130 houses since starting the construction of homes in 1977.

Some 35% of this stock is thought to be older than 20 years. There is a small inventory of 1930 to 1950’s houses that are the source of the majority of the 80 either abandoned or vacant houses on the reservation. There are 5 homes built by the Indian Health Services

(IHS) that are 15 years old. The Dulce School units are comprised of 12 duplexes more than 25 year old, 8 new duplexes, 6 homes, and 10 doublewide trailers. The Bureau of Indian Affairs (BIA) housing was built primarily as duplexes. Of the 46 duplexes, 42 duplexes are older than 33 years with some being as old as 45 years. There are nineteen apartment units and they are more than 25 years old. In addition, the tribe has 6 older homes (15 years) available for short term rental.

This is an inventory of building stock that quite frankly is breathtaking. Virtually every style of design and construction available in the 70 years since the first housing was built exists on the reservation. The inventory exhibits the styles built across all of America's climates. These styles were imported and built on the reservation for the people of the Nation to live in, go to school in, work in and die in. All these buildings ignore the climate and other features of the place that is the Jicarilla Apache Nation. One way to describe the building stock is that it represents all of America's worst practices applied to a very beautiful place entirely out of context.

2.2 Characteristics of a Typical Jicarilla Apache Nation Home

According to the Dulce Housing Survey, the average home on the Jicarilla Apache Nation homeland:

- is less than 1200 square feet;
- is twenty five (25) years old;
- sits on a lot that does not have trees on the southern or western sides and has little if any landscaping;
- has electricity and is heated with natural gas;
- receives its water from the Utility Authority;
- disposes of its waste with the Utility Authority sewer system;
- has a composite roof, single pane windows, and a façade which is failing;
- has five non-EnergyStar appliances, and
- provides shelter for five human beings.

Table 2.1 - Dulce Housing Categories (historical and updated)

	1998	2006
Housing		
Single Family	666	1,041
Mobile Home	144	300
Duplex	56	46
Multi-Family	18	19
Other Buildings		
Commercial		13
Government		40
Industrial		
Institutional		17
		1,476

Table 2.2 - Housing Quality

Housing Condition	% of Total
Standard	74.8%
Need Weatherization	21.2%
Need Replacement	4.1%

Table 2.3 - Occupancy

Category	2006
Total Housing Units	1,406
Total Occupied Units	1,326
Vacant	30
Abandoned	50
Occupancy Rate (based on vacant units)	98%

2.3 Characteristics of Two Institutional Buildings

The authors conducted two onsite inspections and surveys; one in March, and the other in May 2006. The overall impression is that the inventory of buildings is very diverse, ranging in condition from excellently constructed and maintained buildings to abandoned structures that are a potential health and safety risk to the community. The inventory is largely separated along the age of construction. The management of the facilities is also differentiated by age with outsourced personnel providing the maintenance and capital renewal approach to the new structures and tribal employees working with the older structures.

A much more detailed assessment and analysis should be undertaken of the aging inventory before any substantive work is undertaken to address the energy efficiency of the structures. Two commercial examples briefly presented in case study form illustrate the issues and the opportunities.

The first case is the old ***Arts & Crafts Center,*** *formerly the cultural center for tribe. Though the Center has been moved, this case study remains informative in relation to several other buildings on the reservation. The building is a metal building, a kind of building that probably should not have been used for housing a cultural collection. It was in poor repair and ill suited to year round human habitation. There was insufficient insulation to provide minimal comfort in the structure under the best of cases; moreover, the envelope was compromised through the years further reducing the effectiveness of the original system.*

Picture 2.1 - Arts & Crafts Center insulation (north side)

There was a significant water leak coming from a fireplug located on the northern side of the site. The water leak created a cavitation under the slab of the building. As a result, the slab has cracked and runs the length of the building, end to end, causing a safety hazard, a vapor barrier compromise and a visible building maintenance problem. The maintenance staff attempted to address the problem by caulking the gap. However, this was a cosmetic repair at best.

Picture 2.2 - Arts & Crafts Center cracked and caulked slab

The water caused moss to grow on the foundation and the approach to the building. The building had only 2 inches of insulation when it should have at least 6 inches. Thus, the occupants were always cold. There was inadequate electrical capacity for the building. The use of "bandit" electric space heaters was widespread creating another safety hazard. The gas hot water tank had been installed incorrectly and was improperly vented. The overall safety and security for the legacy culture pieces was at risk. Additionally, there was very poor drainage away from building and the handicapped ramp was a hazard. The opportunities were many, and relocation of the Center was the wisest course.

*The **Community Center** building is the second building to highlight. The mechanical system for the offices, pool, and bowling alley is not functioning as a system, and requires balancing. The occupants report numerous hot and cold calls, excessive utility bills and increased sick leave use in the facility. The building envelope has numerous challenges.*

A large and important concern is the basic construction material for the envelope. There are numerous signs of failures, with holes as large as a golf ball penetrating the walls and compromising the performance of the entire facility. This problem is most prevalent on the east and north sides of the building where the bowling alley equipment is located. The failure is so extreme that on some cold days the bowling alley does not even open up because it is too cold for the machinery to operate or for the bowlers to be comfortable.

Picture 2.3 - Community Center Window gasket failing

The storefront aluminum window frames and gasket system is failing. In some instances the gasket is no longer in place.

The mechanical rooms are devoid of any insulation and are frequently used in a manner not consistent with their design. There is an excessive reliance upon incandescent lighting to light the building which could be mitigated by employing compact fluorescents lamps. The 2 x 4 lay-in lights are of a much older generation and should be changed out in favor of much more efficient and effective lighting systems. There is a compromised thermal break between the offices and the swimming pool causing the second floor offices to be uncomfortable and escalating the energy costs of the facility. Major contributing factors to temperature variations in the facility are the undersized and underperforming exhaust fans.

The potential opportunity for energy efficiency measures in the older buildings in the inventory is very high and would have solid economic payback values. The major building issues may or may not have simple payback opportunities but the environmental quality of the facility will improve human health and comfort. There are many opportunities to extend the life of some of these buildings while in other instances there are not. In some instances, the most important long-term strategy may be a commitment to raze the facility.

2.4 Baseline Data

Research on residential housing characteristics from the 2000 census revealed useful baseline data that fit with the Dulce data presented above.

Table 2.4 - Baseline reference data

Pop.	**Housing units**	**Area in square miles**			**Density per square mile of land area**	
		Total area	Water area	Land area	Pop.	Housing units
2,755	972	1,367	3	1,364	2	0.7

Based upon experience and observation (not detailed data), this building inventory represents a substantial opportunity for energy efficiency and weatherization program implementation. Two inspection trips, made in the company of a board member and a utility authority member, provided substantial assistance in making this assessment.

One of the cultural issues to be recognized and respected is the sense of privacy and the sense of sacredness that continues to be expressed by tribal members. This study did not secure data directly from the homeowners. Northern Rio Arriba Electric Cooperative (NORA) provided detailed, anonymous meter data. Analysis of this data served to support proposals relating to weatherization and energy efficiency programs. The data is annual usage and there is no customer-specific demand information.

2.4.1 Data description

The metered data for monthly electricity consumption (in kWh) for residential and commercial units in 2005 was extensively analyzed. The following table gives a breakdown of the available data points and simple statistical description (averages, sum, min, max values).

Table 2.5 - Dulce Energy Annual Consumption by Building Type

Building Type	Annual Energy Consumption values in kWh					No. of units
	Total	**Average**	**Min**	**Max**	**Median**	
Small Commercial Single phase	981,948	15,343	93	112,905	9,357	64
Small Commercial Poly Phase	333,550	27,796	11,935	87,680	20,083	12
Residential	5,057,609	5,521	356	28,597	5,088	916
Large Commercial	10,803,934	284,314	3,423	1,780,200	66,258	37
Residential Time of Use	13,016	3,254	325	7,341	2,675	4

2.5 Commercial Data Analysis

The following tables were constructed from detailed commercial consumption data for NORA customers in 2005.

Table 2.6 - Detailed analysis of annual energy consumption

Building Type	Annual Energy Consumption values in kWh					No. of units
	Total	Average	Min	Max	Median	
Small Commercial Single phase	981,948	15,343	93	112,905	9,357	64

Figure 2.1 – Annual Electricity Consumption, Small Commercial

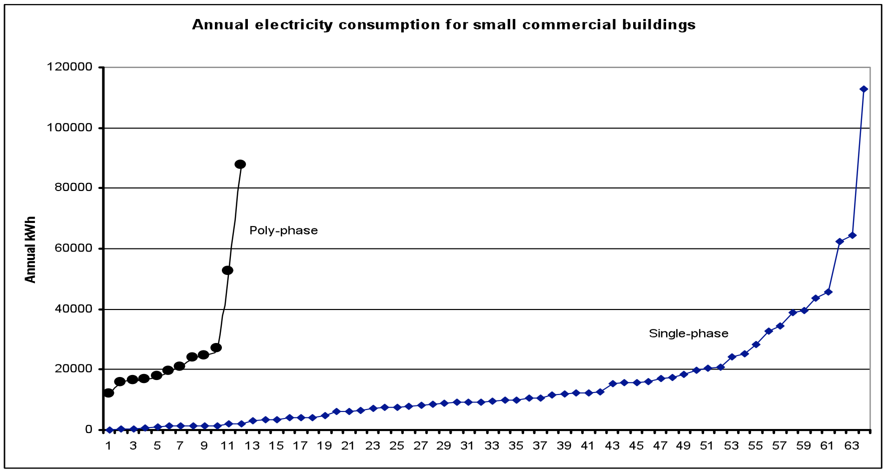


Figure 2.2 – Average Commercial Demand (excl. poly-phase)

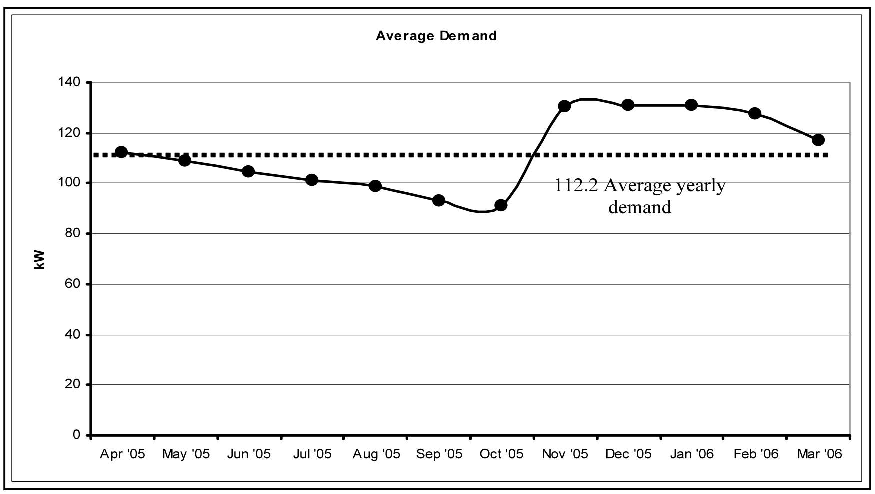


Table 2.7 - Commercial customers grouped according to low, medium, high consumption.

Bin	Count	Average Monthly Consumption (kWh)	Average Yearly Consumption (kWh)	Total Annual Consumption for the Bin (kWh)	Average Electricity Charge ($/kWh)
Low	21	208	2493	52363	$0.189
Medium	21	795	9540	200347	$0.111
High	22	2762	33147	729238	$0.091

2.5.1 Observations and opportunities

The high bin consumers consume relatively more energy in summer (the high to low ratio is the highest during this time) – opportunities for cooling energy reductions in the high group.

Commercial buildings are mostly cooling dominated – there are opportunities for heating energy reductions.

The energy costs are highest for the lowest consumers (almost twice) – a variable base rate would reduce the discrepancy.

2.5.2 Energy efficiency measures

In order to roughly estimate the potential value or "budget" for energy efficiency measures, the aggregate consumption data was analyzed for an indication of the dollar savings available from an "across the board" package of hypothetical energy savings measures. While individual building conditions determine the actual savings potential that could be achieved in a cost-effective manner, this rough estimate allows some initial review of the potential of an efficient buildings program in the commercial sector.

The following two tables depict the average potential reduction in energy costs for each group if their annual consumption is reduced by 10-20% across the board (ATB).

Table 2.8 - Average Reduction in Annual Energy Bill per Customer ($)

Bin	10% ATB	15% ATB	20% ATB
Low	$20.75	$31.13	$41.51
Medium	$79.46	$119.18	$158.91
High	$275.14	$412.71	$550.28

Table 2.9 - Reduction in Annual Energy Bill for the Population ($)

Bin	10% ATB	15% ATB	20% ATB
Low	$436	$654	$872
Medium	$1,669	$2,503	$3,337
High	$6,053	$9,080	$12,106
Total	$8,158	$12,236	$16,315

A typical demand profile was generated, assuming that the peak demand on any given day is twice that of the minimum demand. The following table shows the average reduction in bills for the highest quintile, if peak shaving measures are incorporated.

Table 2.10 - Peak Shaving Reduction in annual energy bill

% Peak Shaving	Reduction in Annual Energy Bill for the Population ($)		
	All months	Winter months (Oct – March)	Summer months (April – Sep)
10%	$2,690	$1,433	$1,257
20%	$5,381	$2,866	$2,514
30%	$8,071	$4,299	$3,772
40%	$10,761	$5,732	$5,029
50%	$13,451	$7,165	$6,286

The following table shows an example of how the customer charge can be varied, based on the consumption group such that the total revenue remains the same, while allowing for a lower overall per kWh charge for customers in the low consumption group.

Table 2.11 - Revenue neutral cost restructuring

Bin	Current Customer Charge ($)	Effective $/kWh	Revenue ($)	Variable Customer Charge ($)	Effective $/kWh	Revenue ($)
Low	$22	$0.189	$9,902	$12	$0.141	$7,382
Medium	$22	$0.111	$22,230	$22	$0.111	$22,230
High	$22	$0.091	$66,339	$30	$0.094	$68,451
Total			$98,471			$98,063
Ratio (high to low)		2.079			1.502	

2.6 Residential Data Analysis

The following tables were constructed from detailed residential consumption data for NORA customers in 2005.

Table 2.12 - Annual energy consumption in kWh

Building Type	Annual Energy Consumption values in kWh					No. of units
	Total	Average	Min	Max	Median	
Residential	5,057,609	5,521	356	28,597	5,088	916

Figure 2.3 - Annual energy consumption in kWh

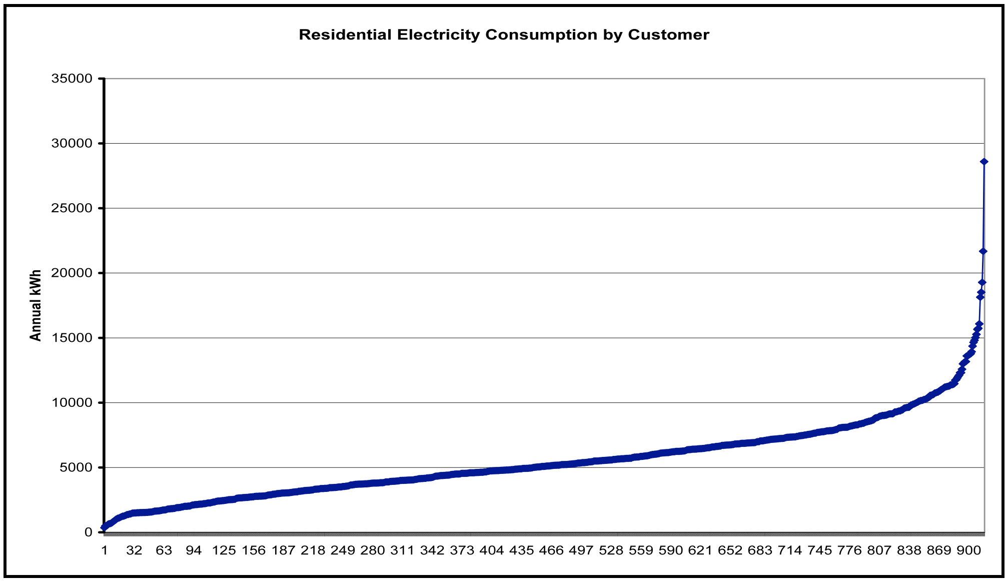


Figure 2.4 - Annual average demand

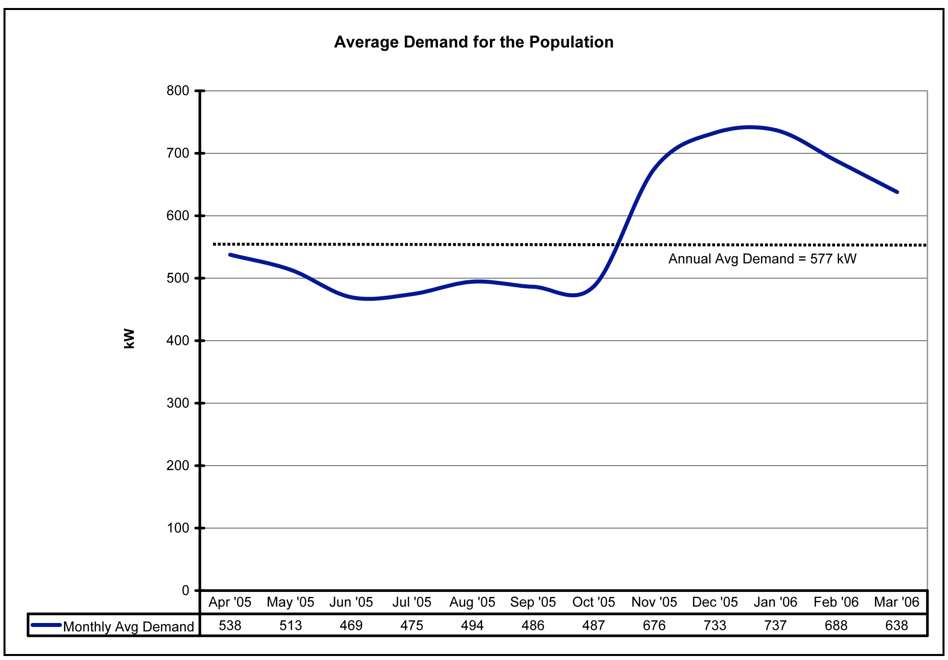
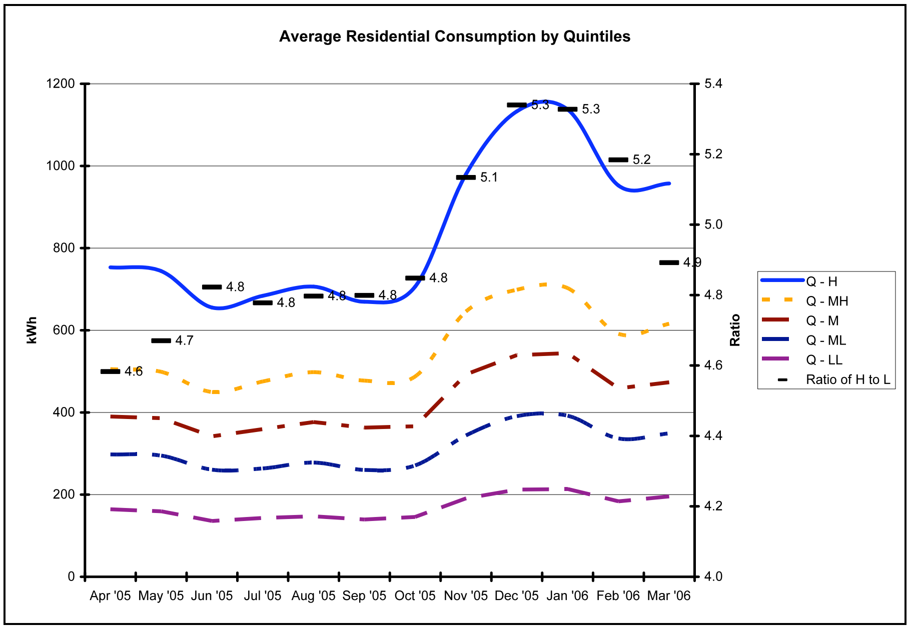


Figure 2.5 - Average residential consumption by quintiles



2.6.1 Observations and opportunities

The high bin consumers utilize relatively more energy in winter (the high to low ratio is the highest during this time) – opportunities for heating energy reductions in the high group.

The energy costs are highest for the lowest consumers (almost twice) – a variable base rate would reduce the discrepancy.

2.6.2 Energy efficiency measures

The following two tables show the average potential reduction in energy costs for each group if their annual consumption is reduced by 10-20%.

Table 2.13 - Average potential reduction in energy bills per customer

Bin	Average Reduction in Annual Energy Bill per Customer ($)		
	10%	**15%**	**20%**
Q - LL	$17	$25	$34
Q - ML	$31	$47	$62
Q - M	$42	$64	$85
Q - MH	$55	$83	$111
Q - H	$84	$126	$168

Table 2.14 - Average potential reduction in energy bills for the population

Bin	Reduction in Annual Energy Bill for the Population ($)		
	10%	**15%**	**20%**
Q - LL	$ 3,091	$ 4,636	$ 6,181
Q - ML	$ 5,688	$ 8,532	$ 11,376
Q - M	$ 7,750	$ 11,625	$ 15,500
Q - MH	$ 10,115	$ 15,172	$ 20,230
Q - H	$ 15,345	$ 23,018	$ 30,691
Total	$ 41,989	$ 62,984	$ 83,978

The following table shows an example of how the customer charge can be varied based on the consumption group such that the total revenue remains the same, while allowing for lower overall per kWh charge for customers in the low consumption group.

Table 2.15 - Revenue neutral cost restructuring to allow for lower $/kWh for low energy consumption group

Bin	Current Customer Charge ($)	Effective $/kWh	Revenue ($)	Variable Customer Charge ($)	Effective $/kWh	Revenue ($)
Q - LL	$15	$0.17	$63,847	$10	$0.14	$52,867
Q - ML	$15	$0.13	$89,822	$12	$0.12	$83,234
Q - M	$15	$0.12	$110,439	$15	$0.12	$110,439
Q - MH	$15	$0.11	$134,089	$18	$0.12	$140,677
Q - H	$15	$0.10	$187,411	$20	$0.11	$198,451
Total			$585,609			$585,669
Ratio (High to Low)		1.70			1.33	

2.7 Green Building

The typical approach to consideration of energy efficiency is to consider the merits and costs of various individual energy efficiency measures. For example, the slightly higher up-front cost of a compact fluorescent light bulb is compared to the costs and energy efficiency penalties of an incandescent bulb. Each added inch or R-factor unit of insulation is assessed by its individual cost. The tonnage of the chiller unit is assessed on an equipment cost basis. But such analysis fails to account for the system interplay of energy efficiency measures in buildings, often biasing decisions in favor of lower up-front costs and against longer term savings.

A simple example illustrates the point. Consider a new residential building or a comprehensive retrofit of an existing building. The conventional approach is to size (and oversize) the heating/ventilation and cooling (HVAC) equipment at a level that ensures comfort under conventional building performance standards. However, if a comprehensive package of energy efficiency measures is considered and implemented first, the capital and running costs of the HVAC system could be substantially less. That is, more insulation, more efficient lighting, better sealing, shading, and more efficient appliances could all lead to a reduction in the capacity requirement and running costs of the

HVAC equipment at a lower overall system cost. This is the thinking behind green building.

2.8 What is green building?

Green building, also called sustainable building, and high performance building, is the term given to a set of emerging practices in the design and construction of new and renovated buildings. Green building strives to balance economic needs and environmental impact with human health and comfort. This is sometimes referred to as the People, Planet, Profit triad, or triple bottom line.

Minimization of building energy requirements is a major factor in the design of sustainable buildings. The Energy Conservation and Management Division is concerned with the optimal use of energy resources to meet our needs while simultaneously minimizing negative impacts to our environment and our dependence on foreign oil.

2.9 The five aspects of building green.

Typically, green building looks at five aspects of building practices: site, water, energy, materials, and indoor environmental quality.

These are the basic categories that make up the Leadership in Energy and Environmental Design (LEED®) rating systems. Developed by the U.S. Green Building Council (USGBC), LEED establishes an objective method of measuring how green a building is. Following is a discussion of all five areas, specifically as they relate to energy.

2.9.1 Site

Site deals with where we build and how we use the site on which we build. Where we build affects how far people have to drive to reach the building; whether or not new infrastructure has to be built to serve the building; and what alternative transportation options are available. Those site considerations all significantly affect personal vehicle use and gasoline consumption. How we use the site includes managing stormwater runoff, reducing heat island effect, and providing quality open space. High levels of stormwater runoff increase the need for pumping and processing water, both requiring the use of energy. Heat island effect can raise the temperature of the surrounding environment by as much as 10° F over an undeveloped location, which results in a higher need for cooling. The connection between open space and energy includes reducing cooling needs, because occupants can open windows and enjoy the fresh air. Open space reduces gasoline use by creating appealing outdoor spaces that don't require driving to the country.

2.9.2 Water

Water addresses both indoor and outdoor use of potable water. As mentioned above, there is a direct relationship between water and energy use because of pumping. All potable water that is delivered to our faucets is pumped. All wastewater that leaves our buildings is pumped and treated. Reducing our water use could significantly reduce that energy use. And, of course, the benefits of water conservation is cannot be overstated or overlooked.

2.9.3 Energy

Energy looks at how much and what type of energy we use. The evidence is clear that global climate change is causing many environmental problems. The emission of CO2, which ties to the consumption of fossil fuels, is known to be impacting global warming. Thus, there is a strong impetus to reduce fossil fuel use. The first step is energy conservation and efficiency, which is the most cost-effective approach. When building energy requirements are minimal, it makes sense to meet them with clean renewable fuels.

2.9.4 Materials

Materials covers appropriate choices for resource management. Embodied energy of a product is the sum of all the energy that is required to mine or harvest the raw materials; process or manufacture the end product; package, warehouse, and transport it throughout the distribution chain; and dispose of the materials at the end of the product's life. Many products made from recycled materials use far less energy than those made from raw materials. Aluminum is a good example. Related to global warming, reducing construction waste by minimizing material use and recycling scraps helps lower the methane emissions from landfills.

Considerable savings can be realized by choosing products that are produced within the local area. This not only saves energy by reducing transportation costs, it improves the local economy.

2.9.5 Indoor Air Quality

Indoor environmental quality assures that buildings are healthy and comfortable for occupants. Health and comfort are the reasons we build buildings in the first place. Ironically, as we progressed in our use of technology, some of the desired outcomes for our buildings actually got lost. Electric lighting led to reduced daylighting. Heating, ventilating, and air conditioning (HVAC) systems led to fewer operable windows. More sophisticated energy management systems led to less individual thermal control of spaces. In all of these areas, taking advantage of natural systems such as daylighting and natural ventilation has been shown to both reduce energy consumption and improve occupant wellbeing. When people have control over their own environment, paradoxically they have tolerance for a broader range of conditions. This in turn results in better use of energy.

2.10 Green Building Case Study

The following case study illustrates the application of green building approaches to a commercial office building in Albuquerque, New Mexico. The building is the U.S. Forest Service Western Regional Headquarters. The construction contractor for the building was Aardex Corporation.

Aardex Corporation has been performing construction throughout the Southwest for the federal government’s General Services Administration (GSA) since 1988. In 2000 they embarked upon a project to provide new regional headquarters for the United States Forest Service in Albuquerque, New Mexico. Following in the footsteps of other Aardex GSA projects, this building was to be a design/build/lease/manage project.

The building combines healthy, team-oriented work spaces that increase employee productivity with numerous energy efficiency measures that have reduced energy costs by 20% over comparable office buildings in Albuquerque.

2.10.1 Project description

The U.S. Forest Service selected a four acre, downtown Albuquerque infill site as the new home for its western U.S. operations. The three-story, 100,000 square foot building includes a full basement, secure parking, Class A office space, a warehouse and loading dock, a 300-person conference facility, and laboratories. Amenities include a full service restaurant/deli and a rooftop plaza. Included in the building program is a Fire Command Center, a 24-hour, 7-day per week operation that is responsible for monitoring wild fires across the region. Home to just over 300 employees, the Forest Service occupied the new building in January 2001.

2.10.2 Building design

Before designing the new building, Aardex architects spent time in the facility the Forest Service was looking to replace, to learn how the building worked, and how Forest Service employees worked in it. This research led to building design decisions that created spaces which promote interaction and teamwork; provided every employee with a view to a window; and included amenities that enable employee needs to be met in the building throughout the day, rather than requiring them to travel off-site. The old headquarters housed 345 employees; through the increased productivity seen through a more efficient space plan and high quality work spaces, the Forest Service now employs 305 people in the new headquarters. Productivity centers and break areas are designed to be nearby to every employee, shortening the distance traveled to reach copiers, printers, and the proverbial water cooler. Increased employee productivity has resulted in direct salary and benefit costs savings to the Forest Service.

2.10.3 Energy efficiency

Numerous energy efficiency measures are employed throughout the building. A dual-level lighting system, set in 2x4 deep-cell parabolic light fixtures with electronic ballasts and T-8 lamps, has been mounted in the building's ceilings. The three bulbs in each T-8 fixture are on separate switches, and can be controlled to work in tandem with the exterior sunlight entering the building. Forest Service employees can turn on one, two, or all three bulbs to best meet their lighting needs, up to a maximum of a 50 foot-candle light level at 30 inches above the floor. These modern fixtures save energy and generate up to 50% less heat than older models, significantly reducing the energy needed to cool the building.

The building's computer-based Building Automation System uses a state-of-the-art direct digital control system, allowing for temperature control and monitoring of building temperature zones; scheduling of temperature zones for occupied, unoccupied, and holiday periods; and preventive maintenance scheduling, amongst other features. Individual thermostat control is provided for temperature zones smaller than 2000 square feet in size, and the computer room has a dedicated air conditioning system designed for the higher cooling loads and humidification levels required by computer equipment. Areas of the building designed for after-hours public use – including the lobby, conference rooms, and rest rooms – are independently temperature controlled.

Carbon dioxide sensors have been installed in all occupied areas of the building. When levels approach 2000 parts per million, ventilation rates are increased to maintain good air quality while minimizing fan energy use.

Windows use an insulating glass unit that combines reflective glass and low-e technology. The exterior light has a reflective coating (PPG Solar-Cool Bronze), while the interior light is low-e (PPG Sungate 1000); combined with the ½-inch air space between the lights, a 1-inch thick insulating glazing system is created that performs well in all seasons.

Aardex works closely with Forest Service employees on computer operations, to be sure that energy saving options are activated and functional. In conjunction with the employee association, an incentive program has been put in place to encourage employees to use energy-saving features on their computers and monitors. Typically, computers and monitors go into energy-save mode after 10 minutes of idle time. While Aardex has not yet completed the required paperwork for ENERGY STAR® certification, the building has been evaluated by Aardex engineers, and it meets the ENERGY STAR® benchmark certification score of 75, in accordance with EPA evaluation protocols.

2.10.4 Heating, ventilation and cooling (HVAC) systems

Throughout the year, Albuquerque experiences classic desert weather conditions – warm to hot during the day, cool to cold at night. The HVAC systems were designed to meet the specific needs of the building uses, and take advantage of the natural cooling that occurs nearly every night of the year. The Fire Command Center, in operation 24-hours per day, 7-days per week, has its own dedicated HVAC system to meet its heating and cooling needs. This allows the rest of the building to function on a more typical work-week schedule.

With cooling needed nearly year-round, the HVAC system for the typical office uses was designed to take advantage of the natural night-time cooling that occurs in Albuquerque. The computer-controlled HVAC system shuts down at 4:45 p.m. every work day. At some point during the night, dependent upon how cold the outside air temperature becomes, the system performs a “night purge” – it exchanges 100% of the now warm building air with cold night air, such that at 7 a.m. the next morning, when employees begin to filter in for the work day, the building has reached a comfortable, pre-determined temperature. During the day, the HVAC system works as necessary to keep the building comfortable for the employees, until the end of the work day, when the process begins again.

Daytime cooling is also done as energy-efficiently as possible. Whenever possible, an economizer system takes advantage of cooler outside air to lower the internal temperature of the building, rather than using electricity to run the compressors in the HVAC system. In addition, the temperature of the incoming air is lowered with the help of an efficient evaporative cooler before entering the cooling system, thus reducing the amount of cooling required of the HVAC, and reducing energy use. The "night purge," economizer, and evaporative cooling all work together to significantly reduce the energy consumption dedicated to building cooling, over that of standard office buildings.

2.10.5 Energy savings

Analysis of the energy bills for the first year of operation revealed that while the building's basic architectural and energy system design was sound, actual on-the-ground system performance was not meeting expectations, as compared to comparable local buildings and computer modeling – energy consumption was higher than predicted. Through an internal investigation, Aardex discovered that the HVAC economizer unit was not operating optimally. After consultation with the equipment provider, the computer-controlled system was set to activate the economizers under a wider range of temperature and humidity conditions, thus pushing system performance up to the expected levels.

With this modification, the building now uses 20% less electricity per square foot than two comparable Aardex Albuquerque office buildings that are each 30% smaller than the U.S. Forest Service Regional Headquarters.

More information is available at the Aardex web site at www.aardex.com.

2.11 How New Mexico is promoting Green Building

In January of 2006, Governor Bill Richardson signed an executive order to improve the energy efficiency and overall sustainability of new and renovated state-owned buildings. In addition to a significant energy reduction goal, buildings over 15,000 square feet must be certified as green using the U.S. Green Building Council's (USGBC) Leadership in Energy & Environmental Design (LEED®) rating system.

In 2007, the New Mexico State Legislature passed a tax incentive for the private sector to design and construct buildings with similarly high requirements. Check the website in coming weeks for more information on the Sustainable Building Tax Credit. This was accomplished through the work of Governor Richardson's Green Building Task Force.

2.12 Passive Solar Design

The least expensive option is the one you never use. Passive solar buildings are intended to work with the inside and outside climate to minimize energy bills and maximize occupant comfort. The key features that separate passive solar buildings from more traditional buildings are described below.

Properly orient building on an appropriate site. Passive solar windows must face within 30 degrees of due south to maximize solar gain in winter and minimize overheating in summer. Deciduous trees on the south and southwest side of the site reduce summer cooling bills. Since these trees lose their leaves during the fall, the windows are exposed to solar energy in winter.

Increase south-facing glass areas. South windows receive about three times as much sunlight as east and west windows in the winter and one-third less sunlight in the summer. This can provide a portion of winter space heating needs.

Reduce or minimize west glass areas. This will reduce summer cooling needs dramatically.

Design with energy efficiency as a primary objective**.** This includes the proper installation of recommended levels of insulation according to the Department of Energy Best Practices Volume 1, Hot and Humid studies, day-lighting strategies, air-tight design, whole building control systems, super low ‘e’ windows with very low shading coefficients and very efficient heating and cooling systems.

Utilize thermal mass. Employ materials such as concrete framed buildings, interior brick walls, brick pavers, and tile to store heat and modulate interior temperatures in both winter and summer.

Use effective window shading and ventilation. Understand the sun’s azimuth and utilize shading devices; active and passive, vertical and horizontal. Employ smart strategies such as outboarding the fire exit stair wells to western façades to reduce summer cooling loads and therefore, needs.

Distribute heat widely. Maximize the number of rooms that can be heated by the passive solar features included in the building's design.

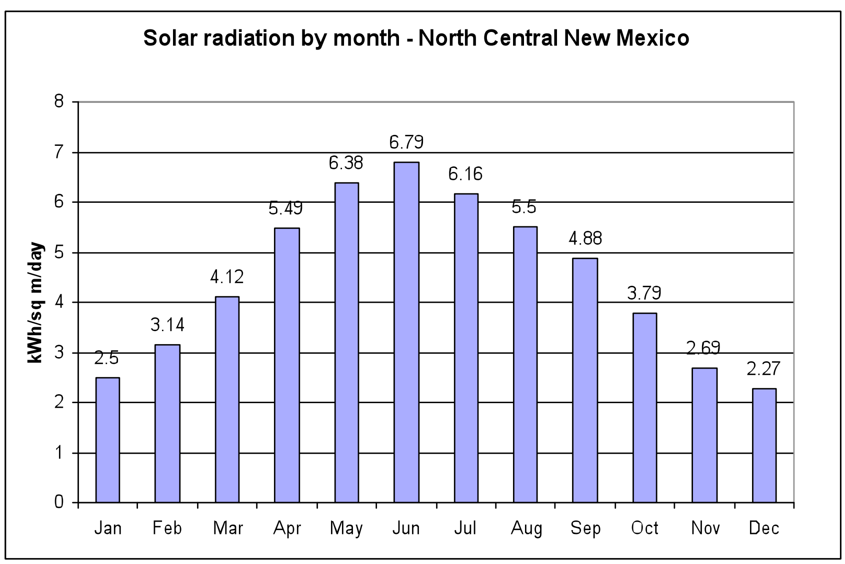
3 Solar Energy

3.1 Resource Quality

Solar energy, or radiation, is quantified by the amount of energy (in kWh) that falls on a horizontal surface of a standard size (square meter or m^2) during a certain time frame. Generalized solar energy maps by National Renewable Energy Laboratory and the New Mexico Energy, Minerals and Natural Resources Department indicate that north-central New Mexico receives an annual average of about 5 kWh/m^2/day (extrapolated from data at Alamosa, Colorado at 5.3, Albuquerque at 5.6, and Chama at 4.9 kWh/ m^2/day). The monthly distribution of the solar energy hitting a horizontal surface follows the same pattern as the height of the sun in the sky, as shown in Figure 1 below.

In a word, the solar energy resource at Dulce is strong. Assuming annual solar radiation at Dulce is similar to Chama's at 4.9 kWh/m^2/day, this would be similar to Los Angeles and Sacramento, California.

Figure 3.1 - Solar Radiation by Month, North Central New Mexico



3.2 *Solar Energy Conversion to Electricity - Technology Types*

3.2.1 Photovoltaics

Photovoltaic (PV) technology is the direct conversion of light into electricity. Light striking certain materials causes the surface of that material to emit electrons. Light striking other materials causes it to accept electrons. The combination of the two materials will cause electricity to flow through a conductor. The individual semiconductor unit that produces direct current electricity is called a cell. The cells are usually made from a silicon-based material, able to convert between 6 and 12 percent of direct sunlight's energy into electricity, though some modern cells can convert more than 20% of available sunlight.

A collection of cells wired together and mounted on a flat panel is called a PV module or panel. Typical panels are about 30" by 60" and can usually generate about 150 watts under full sunlight. Electrical outputs of similar size units may vary because different semiconductor materials can be used and the electrical conversion efficiency varies between materials.

A set of panels wired together into a single electricity producing unit on a rooftop or on a frame is called an array. Electricity produced by the panels or arrays will be direct current (DC). The power output of an array, measured in watts or kilowatts, is limited only by the space available for the modules, which can be mounted on a rooftop or free-standing rack.

The DC power must be converted to alternating current (AC) prior to use by standard appliances. The inverter is the electronic module that converts the direct current electricity to alternating current suitable for end use. The inverter will often also contain system protective circuitry and possibly an interface for viewing electric current.

Because the components of a PV system are modular, the size of the system can vary from a few watts to tens of megawatts. PV panels are relatively maintenance-free, long lasting, and require little ancillary equipment. For these reasons, they are ideal for residential or small-scale community energy projects. Other technologies discussed below may be more cost effective in the larger project sizes (over 1 MW).

Figure 3.2 – Rack-Mounted Array of PV Panels

3.2.2 Concentrating thermal

Concentrating thermal encompasses technologies that concentrate the heat energy of the sun to power a machine that generates electricity. Several different systems of gathering and converting the heat energy are described below.

3.2.2.1 Trough

In the trough type system in the photo below, a semi-parabolic mirror is used to direct sunlight onto a black pipe. The pipe carries oil, or some other liquid that can be heated to high temperatures without boiling, to a central heat exchanger where the hot oil is used to heat another fluid with a much lower boiling point. The vapor from that secondary fluid is used to drive a turbine which then runs a generator to make electricity.

Figure 3.3 - Trough Solar Energy Collectors

In order to keep the sunlight focused on the heat-absorbing pipe, the troughs must track the sun's vertical position in the sky by rotating on their horizontal axis. The type of equipment involved lends itself to assembly in increments of at least 1 MW, with many troughs feeding heated fluid to a common heat exchanger and generator. Several arrays of troughs and generators are usually built at a site to take advantage of assembly and interconnection economy of scale. The largest example of this type of power plant is the Solar Electric Generating Station (SEGS) in California's Mohave Desert with nine power plants totaling over 350 MW.

A 1 MW solar trough power plant built by Arizona Public Service was recently put into service between Phoenix and Tucson. The plant features more than 100,000 square feet of trough-shaped mirrors, and is the first solar trough plant built in the United States in 17 years. It differs from the SEGS plants in that the heated oil circulated through the troughs is used to vaporize an organic working fluid rather than water. The vapor spins a turbine to drive a generator - producing power - and the vapor is then condensed and reused. This is the same turbine technology used in geothermal binary power plants where hot water is used to vaporize the working fluid.

The reported overall cost from large thermal trough solar power plants is about 12 cents per kWh, including the low operating costs courtesy of the free solar fuel. Efforts are underway to reduce construction costs and increase productivity to bring costs in line with conventional fossil-fueled power plants in less than 10 years. Advancements leading the way include thermal energy storage to extend the daily number of hours of electricity generation capability.

3.2.2.2 Solar concentrator tower

The system in the photo below near Barstow California uses an array of sun-tracking mirrors to concentrate sunlight onto a receiver on the top of the tower in the center of the photo. The sun heats a fluid inside the receiver. An early U.S. demonstration plant, Solar One, used water as the fluid, generating steam in the tower to drive a turbine to generate electricity. The plant was later converted to Solar Two, which used molten salt as the fluid. The hot salt could be stored, then used when needed to boil water into steam to drive a turbine.

Figure 3.4 - Solar Energy Concentrating Mirror Array and Tower

These types of projects are very capital intensive and require full-time operator attention, therefore they are best suited for large installations. In order to maximize the investment, these systems will usually be located in areas with very high solar radiation and a minimum of cloudy days.

3.2.2.3 Solar dish concentrator

Figure 3.5 – Solar Dish Concentrator

A dish system uses mirrors in the shape of a dish to collect and concentrate the sun's heat onto a receiver. The receiver then converts the energy into electricity. The difference between this system and the tower system above is that the mirrors and receiver are mounted on a common frame and track the sun as a unit. In the tower system above, the receiver is stationary and the mirrors individually track the sun. The receiver in the dish system is compact by necessity.

One type of receiver to convert the solar energy to electricity uses high-efficiency solar cells. These cells differ from the cells in panel system by being heat tolerant and working with much higher levels of light intensity. Another type of receiver transfers the solar energy to a heat engine—usually a Stirling cycle engine—that converts the heat into mechanical energy, which drives a generator to produce electricity. Another approach, called the open Brayton cycle, passes air through a porous medium in the receiver, causing the air to heat and expand rapidly. The hot air is then fed into a separate gas turbine that drives a generator to produce electricity. Thus far, the Stirling engine type receiver has proven more efficient than the Brayton cycle or PV type receiver.

Concentrating dish systems are not as developmentally advanced as trough systems, that is, they have not been produced in enough quantity to refine the technology and machinery, nor to realize the benefits of mass production. This could change in the future as large Stirling dish arrays are constructed in the Imperial Valley as proposed by Stirling Energy Systems. Stirling Energy Systems is finalizing contracts with San Diego Gas and Electric and Southern California Edison to deploy 800 megawatts of Stirling dish systems, which will establish the manufacturing infrastructure for the systems and foster wider availability for smaller projects. Since each dish has a capacity of 25 kW, projects of almost any incremental size could be built with arrays of identical units.

3.3 Photovoltaics

3.3.1 Review of key issues

The Nation has already demonstrated the operational soundness of PV in a demonstration project. Because PV works with no moving parts, it has high reliability and availability compared to other energy systems. Still, there are a number of much more important issues that have to be addressed in order to get to a successful business case for PV on the Jicarilla Apache reservation.

3.3.1.1 Initial cost and financing

PV systems cost much more than other energy systems when first installed, and because they are a relatively new technology, financing a PV system can be more difficult and complex.

3.3.1.2 Project economics

PV systems only make electricity when the sun shines (“intermittence”), so project economics must reflect longer payback times in many cases. Economics drive the design of PV systems. Because of their high upfront costs, PV systems should be sized to maximize the benefits from available tax credits or other incentives. It simply makes no sense to oversize a PV system.

3.3.1.3 Convenience

Intermittence also impacts the relative usefulness and convenience of PV technology. While no moving parts are involved, off-grid systems need a complementary battery system to provide round-the-clock energy services.

There remain some issues associated with proper placement and installation of PV systems. Systems should not be shaded. They have to be cleaned periodically, especially where dust buildup is a problem. And they need to be installed safe from vandalism or damage by livestock.

3.3.1.4 Public policy

Where ever pollution associated with conventional energy production is ignored or not factored fully into comparative economics, PV will be at a relative disadvantage.

Integral to policy issues are public perception and awareness issues. Customers and system operators need to understand, for example, that grid-tied systems simply will not operate when the grid is down unless special equipment has been installed to allow grid-independent operation (“islanding”).

3.3.1.5 Utility interconnection

Utilities are rightly concerned about grid reliability, safety, and operating efficiency. PV systems are new to most utility operators as well as customers, and education and experience are required. Historically, utility interconnection issues have been a significant cost as well as planning obstacle. Now, many utilities address the issue with clear standards and simplified application processes. Most rules and conditions relate to ensuring safe operation of PV systems, such as those that govern disconnect switches, islanding, and grounding. The overall process has become so standardized that complying with National Electric Code requirements addresses the issues satisfactorily.

As a result of all these factors, a few general conclusions can be drawn. First, the best applications for PV play to its strengths and avoid its challenges. PV ranks highly in augmenting (not replacing) grid power. It is an outstanding option for emergency power systems. Small energy producers will find PV systems an excellent complement to other technologies in hybrid systems. As fuel prices rise, PV is increasingly attractive, though a long view of payback is still required.

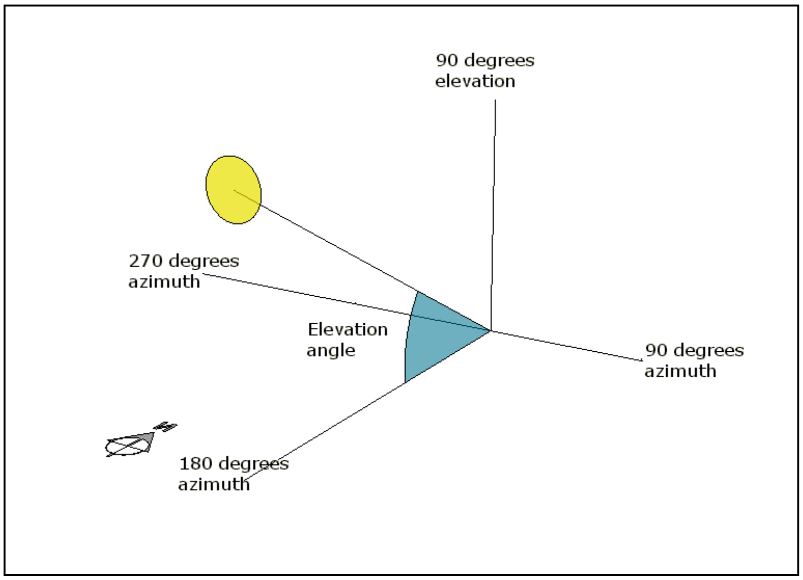
3.3.2 Technical issues – planning and installing a PV system

Photovoltaic technology and equipment are well suited for individual and community-sized solar electric systems. This review addresses technical issues associated with grid-tied systems because of the availability of utility power in Dulce and in many parts of the reservation. Off-grid systems incorporate additional equipment and expense that make it wise to procure the services of a professional involved in the purchase and/or installation of off-grid systems. JAUA has initiated discussions with solar energy hardware and services providers to begin to explore the options in greater detail.

3.3.2.1 PV panel orientation and tracking

A PV panel will produce the most energy when it is oriented perpendicular to the sun's rays, (i.e. facing the sun.) There are two important angles to know in order to describe the sun's position in the sky, and hence determine the orientation of the solar panel. The first angle is the compass direction, or azimuth angle, of the sun's daily east to west motion. The second angle is the Sun's apparent height in the sky, called solar declination or solar elevation.

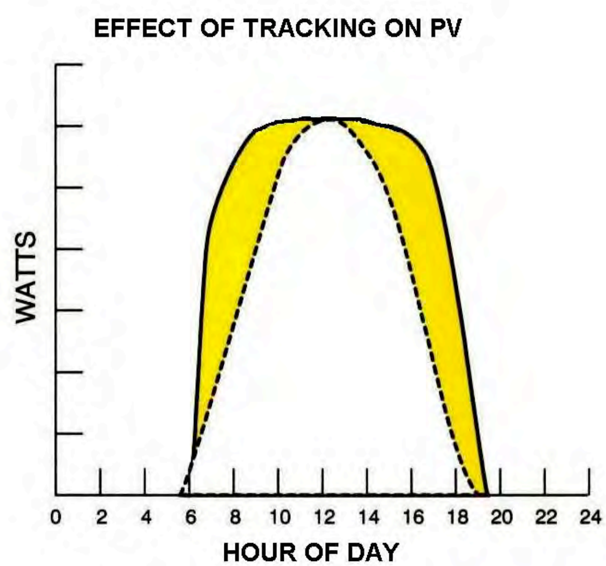
Figure 3.6 – Solar Azimuth and Elevation



When the azimuth term is used to describe horizontal position, the conventional origin for measurements is due north. Therefore, due south is 180 degrees azimuth while east is 90 degrees and west is 270 degrees azimuth. The elevation angle is measured from a level line or the horizon, and will be lower in the winter than in the summer.

Mounting the panel or array on a frame that moves in order to keep the panels facing the sun is called "tracking". Tracking devices can be made to move on one axis or two axes. A single vertical axis tracking device will rotate about the vertical axis and track the sun's azimuth angle as it proceeds from east to west. A single horizontal axis tracking device will rotate about the horizontal axis and track the sun as it rises and falls in the sky. A two axis tracking device will follow the sun both horizontally and vertically across the sky. The approximate improvement in flat panel performance with two-axis tracking over no tracking is shown in Figure 3.7. The area under the dashed line is the fixed panel output, while the tracking increases output as shown by the shaded areas. Peak output is the same in either case, but morning and late afternoon performance are improved by keeping the panel facing the sun.

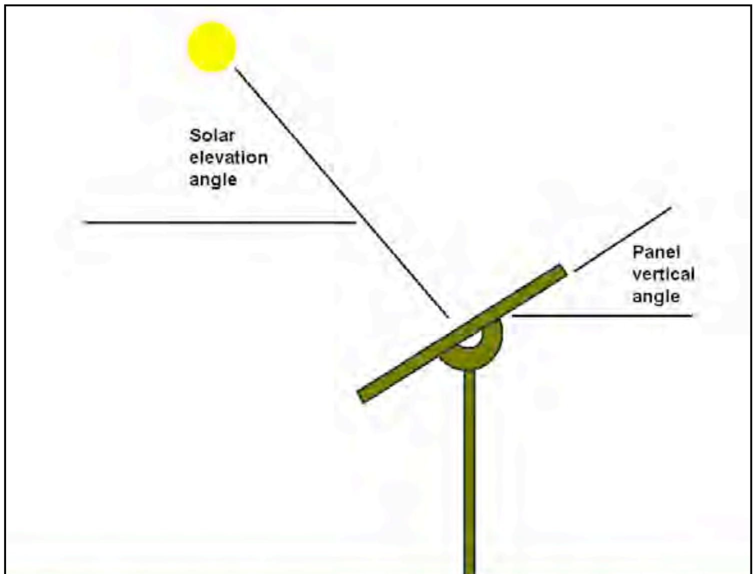
Figure 3.7 – Benefit of Tracking



For a small, residentially sized system, a tracking device may not be economical. That is, the additional energy squeezed out of the system rarely pays for the cost of the tracking equipment and additional maintenance.

If the panel orientation is going to be fixed, that is, no tracking adjustments are going to be made at all, then the panel orientation that would maximize the annual production of electricity is an azimuth angle of 180 degrees, or due south. However, energy output does not suffer very much if the azimuth angle varies up to 30 degrees on either side of south, between 150 and 210 degrees azimuth. The vertical angle should be 37 degrees or less for the Dulce location. The choice of vertical angle, illustrated in Figure 3.8, is subjective and flexible, within limits. A vertical angle of 37 degrees will face the panel at the sun on the spring and fall equinoxes. If winter electricity production is more important than summer electricity production, a higher vertical angle of 45 degrees might be used so the panel is oriented to take advantage of lower winter sun positions. If summertime electricity production is more important, then a lower vertical angle of 20 to 25 degrees would be used to maximize energy production during the late spring and summer days. Many installers use the lower vertical angles, to help with air-conditioner load and de-emphasize winter production when clouds already impact energy output.

Figure 3.8 – Solar Panel Elevation



3.3.2.2 Optimizing solar energy in Dulce

One way to improve solar PV system performance simply and economically is to make manual adjustments to the vertical angle several times a year. These changes will help optimize the panel's angle according to seasonal changes in the sun's elevation. For the Dulce location, a quarterly adjustment schedule like that in Table 3.1 will noticeably improve panel performance.

Table 3.1 – Panel Angle by Season

Season	Panel vertical angle
Mid-April to Mid-August	20 degrees
Mid-August to Mid- October	35 degrees
Mid-October to Mid-February	55 degrees
Mid-February to Mid-April	35 degrees

If it is not possible to orient the panel's azimuth angle to due south, then it is usually best to favor a west of south orientation. That will take advantage of afternoon and evening energy production, which is usually more valuable than morning energy production. Table 3.2 below shows how much energy production is available at less-than-optimal panel orientations. Perfectly flat (horizontal) installations are not recommended because dirt accumulation will reduce the panel's output. Unless there are aesthetic concerns, mounting panels on sloped racks on a flat roof will allow rainwater to clean the panels and leave room under the panels for mounting brackets and wiring.

Table 3.2 – Fraction of Energy Available at Various Mounting Angles

Elevation Angle		Azimuth Angle: West 270	240	210	South 180	150	120	East 90
Vertical	90	0.56	0.64	0.67	0.66	0.67	0.64	0.56
	45	0.78	0.89	0.96	0.98	0.96	0.89	0.78
	40	0.80	0.90	0.97	0.99	0.97	0.90	0.80
	35	0.82	0.91	0.98	1.00	0.98	0.91	0.82
	30	0.83	0.92	0.98	1.00	0.98	0.92	0.83
	25	0.85	0.93	0.98	1.00	0.98	0.93	0.85
	20	0.86	0.93	0.97	0.98	0.97	0.93	0.86
Flat	0	0.89	0.89	0.89	0.89	0.89	0.89	0.89

Fraction of energy available compared to optimum orientation

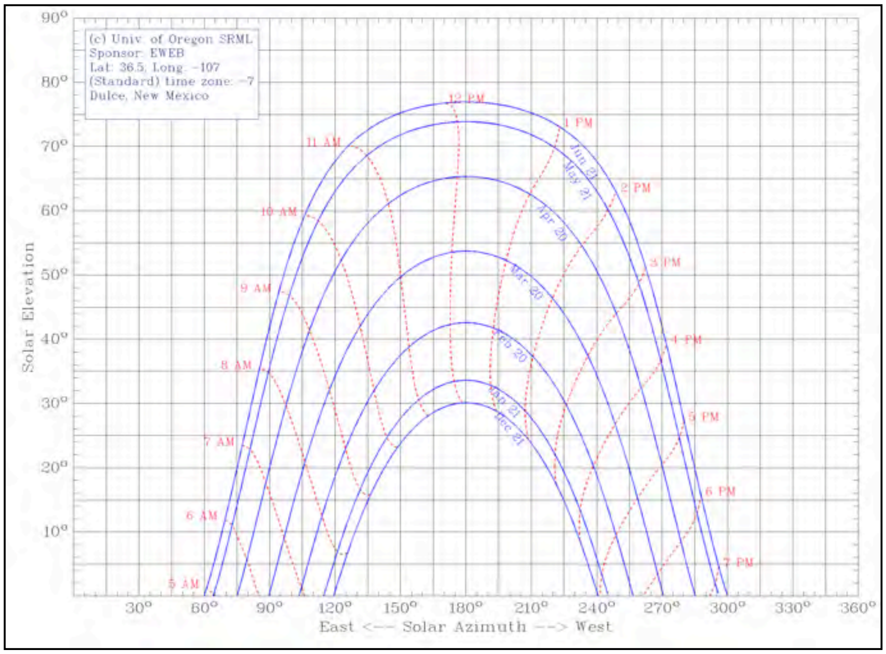
According to Table 3.2 above, a moderately sloped roof does not have to be facing directly south in order to capture a significant portion of the sun's energy. Additionally, note that horizontal panels on a flat roof would produce much more energy than the same panels on a south-facing vertical wall.

3.3.3 Solar access

Shadows cast on the PV module will severely impact their electricity output. This should be avoided, especially at mid-day when the modules will be at their most productive. The simplest way to determine if any obstructions will cast shadows on a future solar panel location would be to observe the location from solstice to solstice (June 21 to December 21 or December 21 to June 21) and note whether any shadows are cast on the location.

Knowing the sun’s path across the sky is another way to determine if there are any obstructions that will impact system performance. The path depends on latitude and the time of year. Figure 3.9 shows the sun's path across the sky in Dulce.

Figure 3.9 – Solar Path and Elevation in Dulce



The Azimuth axis begins and ends at true North, so the 180 degree direction is true South. The degrees proceed clockwise from true North. The Elevation axis begins with the horizon at zero degrees, therefore 90 degrees would be directly overhead. The blue lines trace the sun's path at seven different times of the year, from the first day of winter to the first day of summer. The rest of the year would follow the same pattern, but in reverse. For example, the path of the sun on July 21, one month after June 21, would be the same as on May 21, which is one month before June 21.

3.3.4 Balance of system - inverter

PV panels and small generators produce direct current (DC) electricity instead of the alternating current (AC) electricity that is used in all utility systems, therefore they cannot be directly connected to household wiring. A device called an inverter must be used to convert the DC electricity into AC electricity. Inverters are solid-state devices that regulate the frequency of the AC electricity to 60 cycles per second, regulate the voltage to a constant 115 to 120 volts, and produce a smooth AC wave form that will not damage sensitive electronic equipment such as computers or microwave ovens. Inverters on grid-connected systems must be sized to handle the maximum output of the PV panels. The equipment supplier will be able to match PV panels and inverters to the desired use considering such factors as future expandability, whether the system will be connected to the utility, and what type of appliances will be connected to the system.

Typically, balance of system components cost about the same, in total, as the solar panels used for the installation.

3.4 Types of Installations

3.4.1 Residential PV

Markets for residential scale photovoltaic systems are growing rapidly due to increasingly available financial incentives and growing homeowner desire to minimize utility expenses and dependence. Many vendors and contractors will sell and install complete systems that will do anything from supplementing mid-day energy supply to totally offsetting the daily energy use of the residence. Because traditional home energy use patterns do not precisely match solar panel output as shown in Figure 3.10 below, connection with the utility is still important.

The physical size of a solar PV system can become an issue in residential situations because of limited roof or yard space. It takes 100 to 150 square feet of panels to produce 1 kW, so a typical 3 kW system would require 300 to 450 square feet of panels. The area of panels required varies due to differences in the conversion materials and module configurations used in different brands of panels. Generally, the more efficient panels are the most expensive.

Panels can be split into two or more arrays providing the cabling between them and the inverters can be kept reasonably short. For example, a hip-roof house could be fitted with 200 square feet of panels on a south facing roof and 100 square feet of panels on the west facing roof slope.

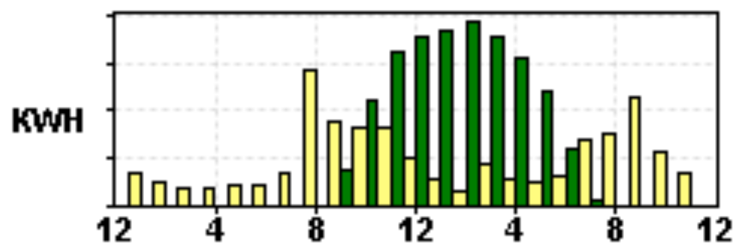
A residential system also includes other components, such as the cabling from the panels to the inverter, the inverter, and the optional disconnect switch. The inverter is a wall-mounted box no larger than an electrical breaker panel. The disconnect switch, if required by the utility, is a shoebox sized switch that must be visible and accessible to utility workers. It is usually mounted near the meter.

3.4.1.1 Solar peak coincidence

As can be seen in Figure 6 for a home with a large PV array, traditional summer energy use - represented by the light bars -

peaks in the mornings and evenings while PV panel output - represented by the dark bars - peaks in mid-day. An arrangement with the local utility to gain credit for the excess energy generated can economically offset the home's energy consumption. This arrangement is known as Net Metering (meaning that the metered and billed amount is the net of the amount produced by the PV system operated by the building occupant) and is discussed in detail below.

Figure 3.10 - Peak Coincidence of Solar PV Output and Load



At this time, NORA and Jemez Mountain do not offer net metering to customers. They also impose conditions on self-installation of such systems.

3.4.1.2 Net metering details

There are two arrangements to account for electricity accepted by the utility from the residential generator - net metering and traditional power sales.

Under net metering programs, the customer is billed for the net electricity drawn from the utility during the billing period. Net means the difference between the total amount of electricity the customer used and the amount furnished by the customer's solar electric generating equipment. Since the equipment is located on the customer's side of the meter, the meter will actually run backward when the solar system is producing more electricity than the customer is using. If the customer's electricity generation exceeds the amount of electricity drawn from the utility, the utility will owe the customer for the net amount of electricity paid at the regular retail rate.

In January 2007, the New Mexico Public Regulation Commission (PRC) extended the availability of net metering to systems up to 80 megawatts (MW) in capacity. Net metering is available to all qualifying facilities (QFs), as defined by the Public Utility Regulatory Policy Act. (In general, "qualifying facilities" under PURPA include renewable-energy systems and combined-heat-and-power systems.) Previously, net metering in New Mexico was limited to systems up to 10 kilowatts (kW) in capacity.

Customers are credited or paid for monthly net excess generation (NEG) at the utility's avoided-cost rate. If a customer has net excess generation (NEG) less than $50 during a monthly billing period, the excess is carried over to the customer’s next monthly bill. If NEG exceeds $50 during a monthly billing period, the utility will pay the customer the following month for the excess. Customer-generators retain ownership of all renewable-energy credits (RECs) associated with the generation of electricity.

All utilities subject to PRC jurisdiction must offer net metering. (Municipal utilities, which are not regulated by the commission, are exempt.) Customers on a time-of-use tariff are permitted to net meter. There is no statewide cap on the number of systems eligible for net metering.

As part of its January 2007 revisions (NMAC 17.9.570), the PRC developed a standard interconnection agreement for systems 100 kW or less. Systems must meet utility safety standards, and system owners must pay appropriate "interconnection costs," as defined in the rule. All QFs are "strongly encouraged to obtain liability insurance." A utility may require QFs larger than 50 kW to obtain general liability insurance not to exceed $1 million. Customers must pay demand charges and other charges in accordance with applicable tariffs, and for any incremental costs associated with installing necessary metering equipment and facilities. Furthermore, an additional customer charge to cover the added costs of billing and administration may be included in a utility's tariff if supported with evidence of need for such a charge.

The PRC's original net-metering rules (NMAC 17.9.571), which are still in effect, include a standard interconnection agreement for systems up to 10 kW and provisions for dispute resolution. An external disconnect switch is also required for these smaller systems. Net metering is accomplished using a single, bi-directional meter. Utilities have the option of paying customers, at the utility's avoided-cost rate, for monthly NEG or providing a kilowatt-hour credit on the customer's next bill.

The PRC has initiated a proceeding to consider interconnection standards and procedures, with the IEEE 1547 standard forming the basis of the commission’s technical interconnection standard. The PRC also will consider a standard set of procedures to streamline the interconnection process between a utility and "all customer-owned generation facilities."

3.4.1.3 Cost

A typical grid-connected residential PV system costs $9 to $10 per watt installed, or $20,000 for a 2 kW system. Relevant to the homeowner is the kWh that may be generated by the system, and therefore used to offset electricity purchased from the utility. Assuming a conservative 15% net capacity factor, a 2 kW system would produce about 2,600 kWh in a year. Energy from systems of other sizes would be proportional, for example a 1 kW system might produce 1,300 kWh a year and a 4 kW system would produce 5,200 kWh a year. The typical Dulce home with natural gas heating and major appliances consumes about 5,000 kWh per year. Monthly output would be proportional to the pattern seen in Figure 3.10.

Although PV generated electricity has no recurring fuel cost or maintenance-intensive moving parts, some allowance needs to be made for preventative maintenance and the occasional component replacement. Preventative maintenance such as periodic cleaning of panels and trimming of landscaping can ensure the continued high performance of the system. Occasionally, a panel or inverter will fail prematurely, in which case the supplier's standard or extended warranty may cover replacement. Product warranties usually run 5 to 10 years, while manufacturers may guarantee panel power production up to 25 years.

3.4.2 Community solar energy

A community energy project is generally defined as one with an energy production capability large enough to serve several homes or businesses, but not so large that the energy production exceeds local energy needs (that is, not likely to generate electricity for export). Community-sized projects are a type of what is often referred to as “distributed generation’—generation systems that are distributed into the grid at small scale. Distributed generation and distributed resources are contrasted to, but can co-exist with, the central station generation model that dominates the U.S. electric grid.

Community projects would not normally be eligible for the net metering program either because of their size (greater than 10kW) or because they are not connected behind a customer's meter. Such a project would be able to sell electricity to the utility under a NMPRC Rule 570 power sales contract. The size of the community solar power project may lend itself to technologies other than PV, such as dish concentrated PV or Stirling engine projects.

Community-size projects can be optimized to reduce strain on capacity-limited distribution systems. Placement of the projects at the load end of distribution feeders helps reduce line losses and the risk of over-capacity failures. The feeder will also operate more efficiently, and, over time, upgrades to the feeder may be deferred because of reduced demand.

Tracking devices on PV systems made possible by the economy of scale on larger systems will increase power production during the morning and late afternoon periods when the utility system is experiencing its peak demands. Dish systems always incorporate tracking devices.

3.4.3 Building integrated PV systems

A PV system that also performs a structural or environmental function for a building, as well as produces electricity, is called Building Integrated Photovoltaics (BIPV). The goal of BIPV systems, in addition to producing usable electricity, is to minimize the aesthetic impact of the solar cells and to reduce costs by having the solar components perform additional functions. These systems have only recently become possible because advances in PV materials have spawned products that can be sized to fit into the building, appear translucent instead of opaque so they can be used in place of windows or skylights, and colored to complement building coloring schemes. PV modules have historically been available only in very dark browns, blues or black, because black is the best for absorbing radiation. Modules are now manufactured in other dark colors, as well as translucent panels, for use in skylights and celestory windows.

Figure 3.11 – Workers Installing Solar Roofing Shingles

PV roofing "shingles" are an example of adapting photovoltaic materials to a building (or residence) component. These photovoltaic (PV) modules are integrated right into roofing materials resulting in a solar system that can be difficult to notice. Photovoltaic roofing replaces existing roofing materials such as asphalt shingles, standing seam metal roofing, and slate or concrete tiles.

PV panels have also been fabricated to match the dimensions of standing-seam metal roofs, which offer electric generating capability to a common building component without adding requirements such as roof penetrations, and support frames. Another example is large translucent PV panels that can be used as a curtain wall in lieu of tinted glass. Translucent PV panels are also well suited as skylights and shelters or awnings where some light transmission is desired and the structure is positioned for solar exposure.

Inverter technology has increased opportunities for building integrated PV by making small, reliable inverters available to place near PV components. This technology also allows the resulting AC power to be integrated into the building's wiring system without having to run expensive DC cables to a central inverter station. Inverter lifetime has not been proven to be as long as PV panels, so access for replacement of inverter modules should be planned into the building.

The economics and aesthetics of BIPV systems are optimized when PV is integrated into the building during preliminary design stages. In order to be effective, BIPV products should match the dimensions, structural properties, qualities, and life expectancy of the materials they displace. Like standard construction glass, cladding, and roofing materials, BIPVs can then easily be integrated into the building envelope.

3.5 Safety

3.5.1 Utility interactive inverters

Utilities who might be on the receiving end of excess electricity generated by a customer's solar power system are concerned, and justifiably so, about the safety of their line workers. This concern is more easily addressed now than ever before because of the increased number of customer installations and the availability of equipment with built-in safety features. Current inverter technology allows for safe home-based customer generation systems. The key is the use of a utility-interactive inverter.

Utility-interactive inverter protective systems are designed to protect utility personnel as well as hardware on both the customer and utility side of the inverter. The protective features address situations where disconnecting the utility interactive inverter from the utility grid is necessary, in which case the disconnection will be automatic and immediate. Those situations include open circuit (an open switch or broken conductor), short circuit (conductor touching the ground or another conductor, whether accidental or intentional by the line crew), and islanding conditions where the customer's system continues to power the residence or business while disconnected from the utility. Automatic re-connection to the utility will not occur unless the inverter senses stable utility operation for a period of time.

A Underwriters Laboratories (UL) 1741 listing and good track record in the market are important criteria in selecting a utility interactive inverter. Several manufacturers provide a range of capacities and features in utility interactive inverters. It is also important to select a qualified contractor or dealer to install the system who is familiar with the National Electric Code.

3.5.2 Disconnect

As a last line of defense, a clearly labeled manual disconnect accessible to utility workers can be installed, providing the utility with an independent way to ensure that the customer's system will not be feeding power to the grid when it is not safe to do so.

3.6 Tools

3.6.1 RetScreen

RetScreen is an Excel spreadsheet decision support tool developed by numerous experts from government, industry, and academia. The software, provided free-of-charge, can be used world-wide to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for renewable energy technologies. The software also includes product, cost and weather databases, and a detailed online user manual. For on-grid applications, the model can be used to evaluate both central-grid and isolated-grid PV systems. For off-grid applications, the model can be used to evaluate both stand-alone (PV-battery) and hybrid (PV-battery-genset) systems. For water pumping applications the model can be used to evaluate PV-pump systems.

Although the online database of solar radiation and climate data is limited to Albuquerque or Alamosa, Colorado, the model can be customized with location-specific monthly solar radiation data. The model can be downloaded at http://www.retscreen.net/ang/pop_prod.php?idTableau=296&h=1.

3.6.2 PVWATTS

The National Renewable Energy Laboratory, at http://rredc.nrel.gov/solar/ has links to tools such as PVWATTS, a performance calculator for grid-connected PV systems. For preliminary study purposes, Version 1 of PVWATTS provides quick and easy access to run multiple scenarios. Data is restricted to the built-in database of NREL solar radiation monitoring sites, which are generally sunnier than Dulce.

3.7 Solar Hot Water

Solar water heating is not new, of course. Long before nearly ubiquitous gas pipelines and electric utilities, people were harvesting the energy of the sun to heat water. Today, over 1 million systems are in use in American homes and businesses. The technology enjoys even more widespread use in the Caribbean basin, Israel, Japan, China, Greece, and Australia.

3.7.1 Key planning issues

The key planning issues relating to use of solar energy to heat water can be grouped in four areas, summarized in Table 3.3, below.

Table 3.3 – Solar Thermal System Planning Issues

Supply	The technology is dependent on a good solar resource. The Jicarilla Apache Nation reservation has an excellent solar resource.
Demand	Demand issues relating to solar water installations include the annual, daily and hourly demand for hot water, the temperature of hot water required, and the volume of demand.
Economic	Economic issues bearing on solar water project evaluation include the level and rate of conventional energy prices (whether gas or electric) and the capital and operating costs of solar systems.
Other Issues	A wide range of other issues can have an effect on the opportunity for and operation of solar water systems. These include the existence and level of incentives, the reliability of equipment and equipment vendors, concern about the environment, and concern about aesthetics, among others.

3.7.2 Screening criteria

Solar hot water is worth considering when the potential project involves:

- A large, daily demand for hot water on a year-round basis,
- The current system of making hot water uses electricity priced at more than $0.055/kWh or natural gas costing more than $8.00/MMBtu
- Tax credits or rebates are available,
- The building is properly oriented toward the sun,
- There is space available near the building or on the roof,
- There is no concern about aesthetics, and
- There is a good to excellent solar resource.

There are several potential opportunities for solar hot water installations on the Jicarilla Apache Reservation. These include the swimming pool at the Community Center, the jail, and several of the multi-unit housing buildings.

3.7.3 Types of solar thermal applications

Solar power systems based on heat are generally divided according to the temperature of heat required. In all cases, a successful solar thermal project involves careful choice of the right application, with a reasonable payback on the initial investment. The technology should be of a proven design, have redundant freeze protection, should be properly sized (undersized rather than oversized), and should require little or no manual intervention. The systems should have easily read and understood operational indicators for monitoring. The system user should explore opportunities to first reduce demand for hot water and maximize current system efficiency before designing the solar water system. System installers should verify load, offer a performance guarantee, provide operations and maintenance manual and training, and provide the results of an acceptance test.

3.7.3.1 Case study – solar thermal applications

Two representative small scale installations reveal the benefits and costs of small scale solar thermal water heater systems. These systems are located at the Chickasaw National Recreation Area in Oklahoma.

Table 3.4 – Solar Hot Water Installation Data

Type of Installation	Small Comfort Stations	Large Comfort Stations
System Size	195 sq. ft., flat plate collectors	484 sq. ft., flat plate collectors
Water Tank Storage Volume	500 gal.	1,000 gal.
System Cost	$7,804	$16,100
Energy Delivered (kWh equivalent)	9,394 kWh/year	18,194 kWh/year
Savings	$867/yr.	$1,789/yr.
Simple Payback	9 yr.	9 yr.

Figure 3.12 - Small Comfort Station with Solar Hot Water Heating

3.7.3.2 Low temperature systems

Low temperature systems provide water at less than 30 degrees C, and are ideal for applications such as swimming pool heating or ventilation air preheating. Low temperature systems use unglazed mats for water heating.

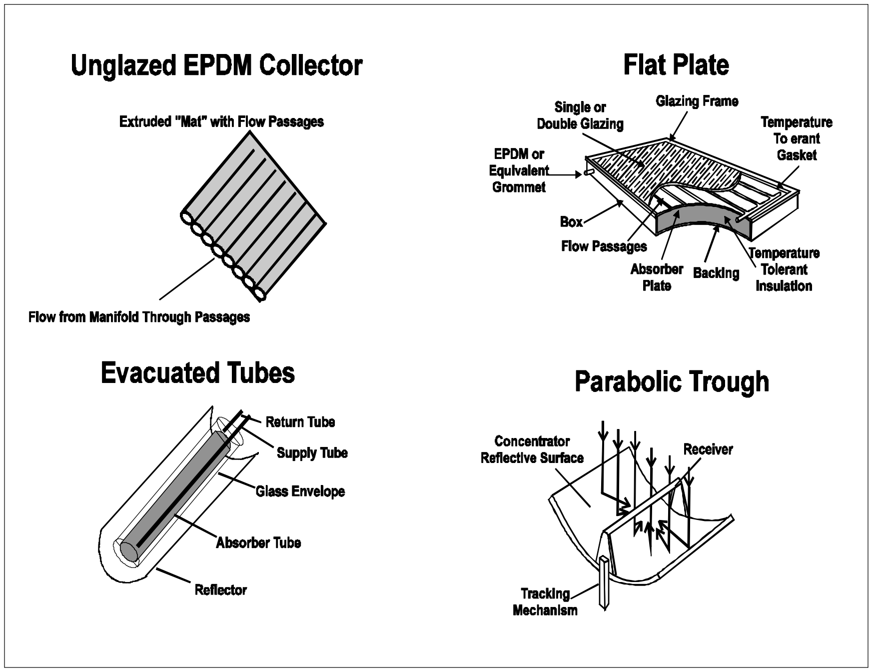
3.7.3.3 Medium temperature systems

Medium temperature systems provide heated water in the temperature range of 30 to 100 degrees C. Medium temperature systems include domestic/residential water and space heating, commercial cafeteria, laundry, and hotel facilities, and some industrial process heat applications. The systems use glazed and insulated collectors.

3.7.3.4 High temperature systems

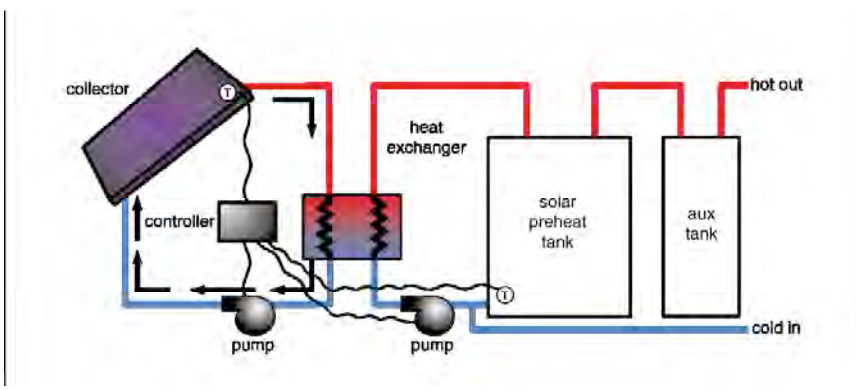
High temperature systems operate at more than 100 degrees C, and can provide heat for industrial processes and electricity generation. These systems require sophisticated equipment such as evacuated tube collectors or focusing collectors.

Figure 3.13 - Solar collector types



3.7.4 System technical details

Figure 3.14 - Solar Thermal Water Heater System



3.7.4.1 Peak power

A typical residential solar water heating systems (SWHS) for a family of four delivers 4 kilowatts of electrical equivalent thermal power when under full sun and when the temperature of the water in the storage tank is about the same as the air temperature. Such a system typically has about 64 square feet (6 square meters) of solar collector surface area and produces approximately the same peak power as 400 square feet (37 square meters) of photovoltaic panels.

3.7.4.2 Production capacity

Ratings of collectors and systems, along with other information specific to the local area, can be used to calculate the specific reduction in a utility's peak demand. On average, for every system that is installed, 0.5 kilowatts of peak demand is deferred from a utility's load.

3.7.4.3 Energy production

Because peak performance occurs infrequently, a more realistic indication of solar thermal system performance is the rated daily energy output of the collectors or system. Using this method, a typical SWHS contributes 7 to 10 kWh per day, depending on the solar resource and the type of collector. Electric water heating for residential applications typically consumes about 12 kWh day, depending on ground water temperature. Annual, site-specific energy savings for domestic water heating systems are available at www.solar-rating.org for all systems certified by the Solar Rating and Certification Corporation. Using this data, a typical SWHS produces about 3400 kWh per year, depending on local conditions and type of collector.

3.7.4.4 SRCC rating procedure

The Solar Rating and Certification Corporation (SRCC) is a non-profit organization whose primary purpose is the development and implementation of certification programs and national rating standards for solar energy equipment. The SRCC was incorporated in October of 1980 as an independent third-party certification entity. It is governed by a twelve-member board of Directors with representation from the public, private and generalist Sectors. It is unique in that it is the only national certification program established solely for solar energy products. It is also the only national certification organization whose programs are the direct result of combined efforts of state organizations involved in the administration of standards and an industry association.

The combined programs of the Solar Rating and Certification Corporation provide onetime certification, national recognition, product credibility, and standardized comparisons of solar energy products. The SRCC programs serve three primary constituencies: the solar energy industry, solar consumers, and state and federal regulatory bodies. All three constituencies benefit from the SRCC programs by obtaining a national state-of-the-art rating system, a mechanism to develop consumer confidence, and a rational and defensible criterion for tax credit qualification and other solar incentive programs.

The OG-300 certification program for solar water heating systems was established in 1992. It integrates results of collector tests and system tests with evaluations against minimum standards of system durability, reliability, safety and operation; as well as factors affecting total system design, installation, maintenance and service. A copy of the certification requirements is available from SRCC.

3.7.4.5 Performance estimation procedures

SRCC uses a computer model to estimate the thermal performance of solar water heating systems under specified conditions. A separate computer model for each system is developed from test data on some of the system components, manufacturer's literature on the others, and theoretical calculations. The SRCC rating is calculated using the computer model is called the Solar Energy Factor. It is published in a Directory and in a summary booklet. These ratings are based on conditions similar to the ones defined by the U.S. Department of Energy for testing conventional water heaters. These conditions describe hot water usage for a single day. Keep in mind that these ratings are only estimates based on an assumed set of operating conditions and that actual performance will vary depending upon hot water usage pattern and actual weather conditions.

The estimated annual performance indicators given in the attached tables are different from the SRCC ratings and are not directly comparable. The annual performance listed in this booklet was developed to provide an estimate of how solar water heaters could perform over a whole year in a specific location. The SRCC rating estimates the performance of the systems under "rating" conditions. Once again, keep in mind that these ratings are only estimates.

For reference, a conventional 50 gallon electric water heater with an energy factor of 0.9 would consume 4,300 kilowatt hours (kWh) per year under these conditions and a 50 gallon gas water heater with an energy factor of 0.6 would consume 215 therms (including delivered energy and losses).

4 Wind Energy Resource – Small Scale

4.1 Introduction

This chapter will examine the hardware and preparations that are needed to produce electricity on a small scale using the power of the wind. In this case we will define small scale as a wind energy project size that does not produce so much energy that it would be exported out of the Dulce area. The size can vary from a few kilowatts that would augment the power supply at a residence or farm, to a few hundred kilowatts that could be fed into the local distribution system and reduce the amount of power imported from outside the reservation. This chapter is also limited to grid-connected wind turbine applications, including those where the wind turbine feeds a home or business that is also connected to the local utility.

Remote, non-grid connected wind systems require batteries or other storage devices in order to provide service. In this regard, they are very similar to small, remote PV electric systems.

The electricity output of a wind turbine connected to a home or business will rarely match the user's power needs at any given moment. For this reason, a utility connection is valuable because it is like connecting to an infinitely sized battery. Grid connected small wind turbines can provide benefits to the utility also. In areas like Dulce or Teepee Junction that have long feeder lines, they can improve power quality and reduce line losses by reducing the amount of electricity carried by the feeders.

If a connection to the utility grid is not available or feasible, then a hybrid system with solar panels, a fuel-powered generator, and/or a bank of batteries would have to be implemented.

4.2 Small Wind Power Machinery

4.2.1 Types of small wind machines

Small wind machines first appeared in the 20's and 30's at rural residences and farms prior to the arrival of the rural electric distribution systems. At least one of the brands available then is still available today—the Jacobs Wind Energy System. Jacobs is joined by many new designs introduced in the last 20 years. Today’s small turbines borrow from aerospace technologies with sophisticated, yet simple designs that allow them to operate reliably for up to a decade or longer without major maintenance. As small wind turbine technology has matured, the products have become mechanically simpler and more robust. Recently improved inverter technology combines the controls and protection systems necessary to connect directly with the utility grid, making small wind turbine deployment increasingly feasible.

Wind turbines generate electricity by spinning a generator. The spinning force can be extracted from the wind with propellers facing the wind and spinning about a horizontal axis as in Figure 4.1 and 4.2, or with vanes or cups spinning about a vertical axis as in Figure 4.3. The former is referred to as a horizontal axis wind turbine, or HAWT, and the latter is called a vertical axis wind turbine, or VAWT. A HAWT can be oriented with the propeller, or blades, oriented upwind of the tower or downwind of the tower. Of the three types, the upwind horizontal axis wind turbine is the most popular and is widely available in many sizes. Small turbines under 100 kW only have 3 to 4 moving parts for high reliability and low maintenance. They are designed to last about 30 years and manufacturers have benefited from the experience gained from thousands of installations.

Figure 4.1 - Typical 10 kW Wind Turbine, Horizontal Upwind Style

The classic upwind horizontal axis wind turbine shown in Figure 4.1 consists of two or three long, narrow blades connected to a hub. The hub is connected to the shaft that drives the generator, usually inside the body of the wind turbine. Small turbines typically have a tail attached at the downwind end to keep the blades faced into the wind, and also possibly provide the leverage to turn the blades away from the wind if that technique is used for power regulation or protection. The body of the turbine is mounted on top of a pole or tower with a yaw bearing that allows the turbine to rotate freely to face the wind.

Figure 4.2 - Horizontal Downwind Turbine, 50 kW Capacity. Photo Courtesy AOC Corporation.

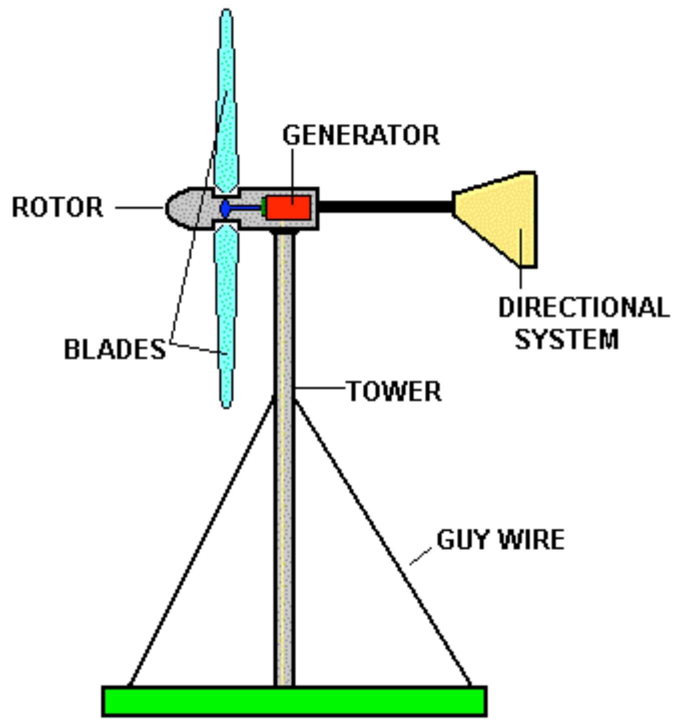
The “downwind horizontal axis” wind turbine is a wind turbine with blades are downwind of the tower, so approaching wind passes the wind turbine body and tower before encountering the blades. An advantage to the downwind configuration is that the force of the wind naturally pushes the rotor downwind so it is perpendicular to the wind direction, whereas the upwind configured wind turbines require a tail or a yaw control motor to turn the blades into the wind. A disadvantage of the downwind configuration is that the tower interrupts wind flow and creates turbulence for the blades as they pass downwind of the tower. This creates a vibration every time a blade passes through this 'wind shadow.' Medium and small wind turbines can be built to withstand this vibration but virtually all large turbines are of the upwind configuration.

Figure 4.3 - Vertical Axis Wind Turbine by Flowind.

Many experimental and prototype vertical axis wind turbines (VAWT) of various sizes and styles have been tested during the search for the ideal wind energy conversion device. However, for several reasons, most have not been commercially successful. One reason is the area rule, which refers to the cross-sectional area of wind being intercepted and converted to energy. Relatively few pounds of material can be fashioned into blades for a horizontal axis wind turbine to sweep many square meters of wind area. To intercept the same area with a vertical axis wind turbine requires a huge structure. Another reason is that half of the vertical axis turbine structure is actually traveling upwind, meaning much of the work of the downwind traveling airfoils is wasted in dragging the opposing airfoils against the wind. A third reason is most VAWTs are mounted on the ground because of their size. This arrangement cannot take advantage of the more laminar (smoother) and higher speed winds found above ground level.

4.2.2 Components

Figure 4.4 - Major Components of a Small Horizontal Axis Wind turbine



4.2.2.1 Blades

Blades for small turbines are typically constructed of aluminum, fiberglass, or plastic.

Typical blade diameters are:

- 400 watt output = 3.7 feet (AirX)
- 1000 watt output = 10 feet (Whisper H80)
- 3000 watt output = 15 feet (Whisper 175)
- 10,000 watt output = 23 feet (Bergey XL)
- 17,500 watt output = 26 feet (Jacobs 26-17)

4.2.2.2 Generator

The generator may be a DC generator or an AC alternator. If AC, the electricity will be of varying frequency and not be suitable for direct connection to a utility system, so the electricity will have to be rectified to DC power. The electricity will then be converted to utility-quality AC power by an inverter. The most common type of generator in a wind turbine below 20 kW capacity is a permanent magnet generator which is relatively maintenance free but requires an inverter.

4.2.2.3 Directional system

To keep the blades facing upwind, small upwind wind turbines will have a downwind vane to counteract the tendency of the generator to rotate away from the wind. In some wind turbine models, this vane is also used to provide the force to turn the blades parallel to the wind in high wind speeds.

Directional vanes are not practical on large upwind turbines of 100 kW and above. Those turbines actually have wind direction sensors and a motorized pivot system to turn the generator and blades into the wind. Such systems are prohibitively expensive for small turbines.

4.2.2.4 Wiring

The amount of current (amps) that must travel through the wires from the generator to the inverter can be quite high at the low voltages used by small wind turbines. Most models are available to operate between 12 and 48 volts. The wind turbine manufacturer's installation instructions will specify minimum wire sizes factoring in the maximum power output, voltage, and the length of the wire run from the generator to the inverter. If the particular installation involves a long run of wire, it may be cost-effective to opt for a larger wire size in order to reduce the energy lost to resistance in the wire.

4.2.2.5 Balance of electrical system - inverter

Wind machines, like PV panels and other small generators, produce direct current (DC) electricity instead of the alternating current (AC) electricity that is used in all utility systems, therefore they cannot be directly connected to household wiring. A device called an inverter must be used to convert the DC electricity into AC electricity. Inverters are solid-state devices that regulate the frequency of the AC electricity to 60 cycles per second, regulate the voltage to a constant 115 to 120 volts, and produce a smooth AC wave form that will not damage sensitive electronic equipment such as computers or microwave ovens. Inverters on grid-connected systems must be sized to handle the maximum output of the wind machine. The equipment supplier will be able to match wind machines and inverters to the desired use considering such factors as future expandability, whether the system will be connected to the utility, and what type of appliances will be connected to the system.

4.2.2.6 Tower

Wind turbine suppliers will usually offer several styles and heights of tower to match the wind turbine. The supplier's involvement is important because different wind turbines impose different loads on the tower that have to be taken into account in the design and installation of the tower. For different wind turbines of equivalent rated power output, the weight and the side force they impose on the tower can vary greatly.

Maintenance is also a consideration when choosing a tower style. A lattice style tower, either guyed or free standing, can be climbed to perform maintenance. Lattice and monopole towers can be configured to tilt down if the wind turbine is not too heavy. Guyed pole towers that are tilted down for maintenance need to be designed to withstand hoisting load because light towers are prone to buckling. Even though maintenance should be required no more than about once a year on a small wind turbine, an expensive crane or bucket truck rental for maintenance will quickly consume a year's profits.

4.2.2.7 Guys

A guyed tower is generally most economical for small wind turbines. A self-supporting tower, without guy wires, must be rigid enough to withstand the substantial side forces the wind turbine imposes on the top of the tower, and also must have a substantial foundation to keep the tower vertical. Where space is available to anchor guy wires, the tower structure itself can be light and less obtrusive visually.

Guy wires are an often overlooked maintenance item. Guy wires must be maintained at the required length and tautness to keep the thin tower in alignment. Out-of-alignment towers loose their structural strength. If the guys or anchors slip or stretch, the tower can collapse.

4.2.3 Planning considerations

4.2.3.1 “1-2-3” rule

The 1-2-3 rule refers to the three factors that affect the output of a wind turbine - air density, area of wind intercepted by the turbine, and wind velocity.

“1” stands for Air Density, to which power output is directly proportional. Wind turbines are usually rated at a standard sea level air density, so almost any other location will result in a de-rating. A 10% decrease in air density due to elevation will result in a 10% decrease in power output.

“2” stands for Area. Wind turbine output is proportional to the square of the blade length of a horizontal axis wind turbine, because the output is proportional the area of the wind intercepted by the wind turbine. The 2 rule states that a 10% increase in the length of the blades and diameter of the wind turbine rotor should result in a 21% increase in cross-sectional area and power output (1.10 x 1.10 = 1.21), assuming other components, such as the generator, have the capacity to take advantage of the output.

“3” stands for Velocity. Wind turbine output is proportional to the cube of the wind velocity. For example, a 10% increase in the wind velocity should result in a 33% increase in power output (1.10 x 1.10 x 1.10 = 1.33). A 25% increase in wind velocity will almost double the energy output.

There is not much a person can do about air density, because that is dictated by the site elevation and climate. The wind turbine supplier must account for air density in estimating power output, and may recommend optional equipment or a different turbine configuration. Any energy output estimate or guarantee should be adjusted for local conditions. The high elevation of the Dulce area will result in a de-rating of about 30% from a wind turbine's sea level performance. Because of the squared rule for rotor diameter versus wind turbine output, that 30% penalty can be offset by a 14% increase in blade length.

The diameter of the wind turbine blades will usually be determined by the power output needs of the user. That is, the wind turbine blade diameter will be dependent on how many kilowatts the user needs to supply his equipment or how much energy the user wants to generate to offset his utility bill.

Wind velocity is the single most important variable that a wind turbine owner should try to optimize. One might think this is another variable that an owner might have little control over at his site, but because of the cubed rule a slight change in location to place the turbine in higher velocity or more consistent wind will yield comparatively large changes in power output. For example, a site with 16-mph average winds, all other things being equal, will generate nearly 50% more electricity than a site with 14-mph average winds. Therefore, prospecting a piece of property for a clear and obstruction-free spot for a wind turbine may dramatically affect the turbine's productivity.

4.2.3.2 Tower height

Wind speed near the ground is slowed and made more turbulent by obstructions on the ground. In the height range where most small wind turbines are mounted, 120 feet or lower, those effects are quite pronounced. Taking measures to avoid turbulence will improve the life of the turbine as well as increase power production. It is a fortunate coincidence that locations with less turbulence, such as higher tower heights, usually also have higher average wind velocities.

Putting a small wind turbine on a short tower is like putting a solar panel in the shade. An owner can more than double the output of his wind turbine by raising it from a 60 foot tower to an 80 foot tower, and can more than triple the output of his wind turbine by raising it from a 60 foot tower to a 100 foot tower. A small turbine on a tall tower is less expensive than a larger turbine on a short tower yet it may produce as much or more energy.[1]

4.2.3.3 Siting

The small scale wind energy projects contemplated in this chapter will have to be located near the buildings where the energy will be used, or near an existing distribution line that can accept the electricity. Relatively few small wind projects can support the cost of long transmission lines for delivery of the power. Also, electric losses due to resistance can be significant at the low voltages typically generated by these machines.

Local topography can work to enhance or detract from wind turbine output. The ideal location is on a slight ridge perpendicular to the prevailing wind direction where the approaching wind accelerates as it squeezes over the ridge. However, too abrupt of a ridge will slow the wind and create turbulence. A turbine located in a saddle may benefit from concentrated wind flowing through the saddle, but at other wind directions the topography on either side of the saddle may block the wind.

Obstructions such as buildings and trees will disrupt the air flow for quite some distance above their height. Trees will grow so the landowner should get some idea of what their height will be at maturity. A rule of thumb is to put the turbine on a tower that will place the blades at least 30 feet above the tallest obstruction that is within 150 feet of the turbine location. The maximum obstruction height plus the blade length plus 30 feet would yield a minimum tower height. Setting the wind turbine on a taller tower will yield additional energy, while setting the wind turbine on a shorter tower will subject the turbine to stress and cyclic loads due to turbulence, in addition to reducing energy production.

Wind turbulence will significantly affect a turbine's reliability. The frequent direction changes, speed changes, and side loads create stresses on wind turbine components that will shorten their life. Not so obvious is the stress caused when the tower is not tall enough to get the rotor into a region where air flow is as strong at the bottom of the blade's travel as it is at the top. Imagine a blade rotating several times a second from higher wind speeds above the

[1] Sagrillo, Mick, "Incremental Tower Costs Versus Incremental Energy", Small Wind Column, AWEA Windletter, February 2006

axis to lower wind speeds below the axis. After a few million of these cycles, blade deterioration due to repeated flexing will occur.

4.2.3.4 Wind resource characterization

A wind resource characterization study is essential in order to estimate wind speeds and ultimately determine power production and the optimal site for the turbine. The accuracy and precision of the energy estimate will rely on and be only as good as the accuracy and precision of the wind speed measurement. Several methods are described below, roughly in order of their usefulness.

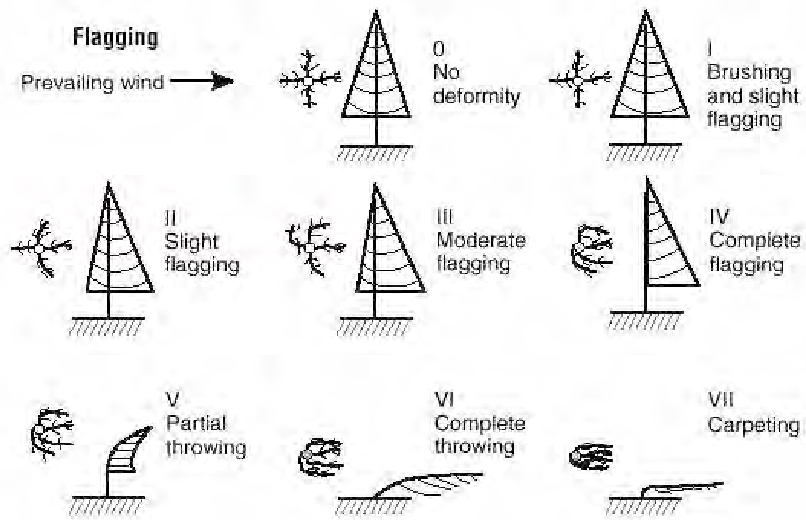
Flagging

Plants subjected to frequent winds often grow unevenly. By measuring the amount of deformation, the average annual wind that has affected that plant can be estimated. This method is not precise and only provides a general indication of the average wind speed at the location of the vegetation. Wind speed and power may be different at wind turbine hub height. The most popular index is the Griggs-Putnam Index which is best applied to conical-shaped evergreens.

Terms used in the Griggs-Putnam Index of Deformity below have the following meanings:

- Brushing – small limbs of a tree are bent downwind giving the branches a “brush” appearance.
- Flagging – large limbs are bent downwind and upwind limbs are shorter than downwind limbs.
- Throwing – the trunk of the tree is curved downwind.
- Carpeting – the trunk of the tree is bent nearly to the ground.

Griggs Putnam Index



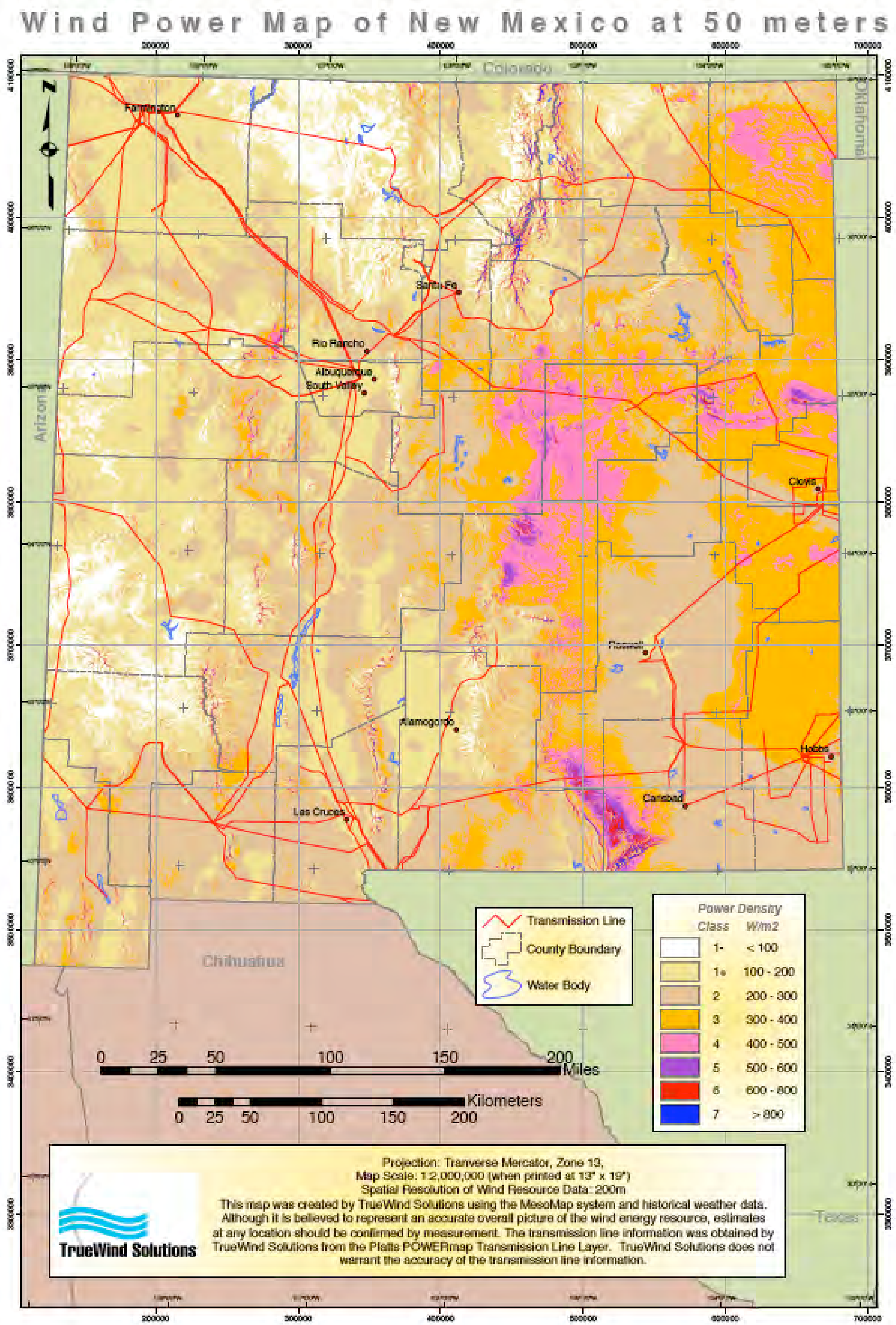
Griggs-Putnam Index of Deformity

Index	I	II	III	IV	V	VI	VII
Wind, mph	7-9	9-11	11-13	13-16	15-18	16-21	22+
Speed, m/s	3-4	4-5	5-6	6-7	7-8	8-9	10

Maps

Various state and federal agencies have funded the development of state wide wind speed maps that show expected annual average wind speed applicable to general geographic areas. These maps are useful to scout for windy areas or roughly estimate the wind strength at a particular site. Because they cover such large areas, they do not take into account local anomalies, like smaller ridge lines and valleys that affect local winds. They may also present data in different manners, such as wind speed at 50, 70 or 80 meters or wind power density at a certain elevation represented in kilowatts per square meter. A 50 meter wind speed map for New Mexico appears on the following page.

Figure 4.5 – Wind Power Map



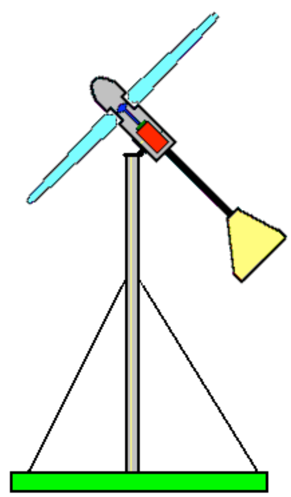
4.2.3.5 Output regulation

One of the key characteristics of large wind turbines that make them efficient energy producers is the ability to regulate their power output by changing the pitch of the blades. Long blades are needed in order to generate energy in low wind conditions, but they would quickly overpower the generator in high wind conditions. The mechanical and electrical systems to adjust the pitch of wind turbine blades cannot be economically installed in small wind turbines. Without the ability to change the pitch of the blades in higher wind conditions to match power generation to the generator's capacity, other measures have to be taken. Several other ways of either regulating power output or withstanding high winds are listed below.

Tilting

Tilting uses the force of the wind to tilt the entire wind turbine back on a horizontal hinge, resulting in the rotor angling away from the wind as shown in Figure 4.6. When the wind dies down, the wind turbine falls back down to a horizontal orientation.

Figure 4.6 - Tilting Method of Speed Control



Blade Furling or Feathering

Blades on small machines can be designed to either bend backwards or twist sideways to reduce the torque produced by the rotor.

Side Furling

Side Furling uses a tail to rotate the rotor up to 90 degrees relative to the wind direction as shown in Figure 4.7. This can occur gradually to provide some regulation, but there is some vibration and noise when the rotor is partially angled out of the wind direction.

Figure 4.7 - Whisper Wind Generator Turned Out of the Wind

Blade Stalling

Blades are specially designed to experience aerodynamic 'stall' at high wind speeds, reducing the torque input into the generator.

Figure 4.8 - Effect of Regulation Techniques

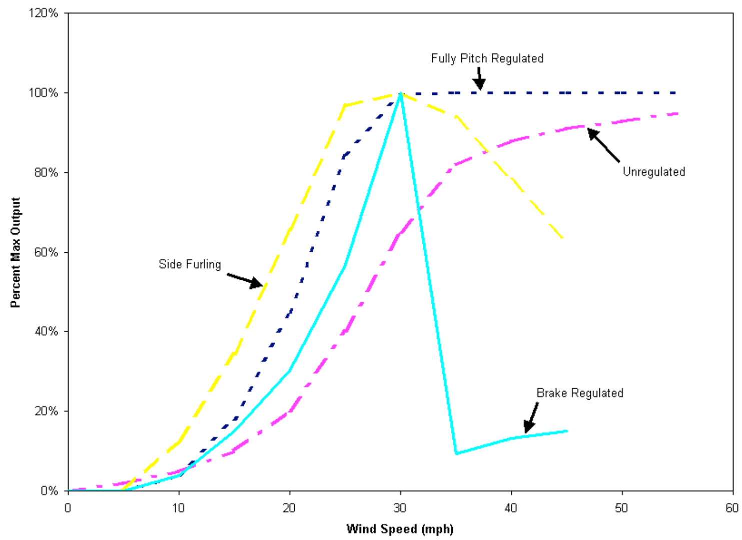


Figure 4.8 shows the effect of various regulation techniques on part-load operation. This illustrates the importance of wind resource analysis in order to estimate the percentage of time wind speeds will fall in the 5 to 30 mph range. At these speeds, turbines vary significantly in output. The character of the local wind regime, especially extreme conditions, will have a strong impact on which regulation method is most appropriate. For example, a non-regulated turbine might produce well at ocean shore locations where there are frequent and sustained 25 mph winds, but it would perform poorly in 10 mph winds. A turbine built to take advantage of lower speed winds and yaw to the side at 25 mph to protect the generator, may be best suited where wind speeds average 10 mph and rarely exceed 25 mph. The wind turbine supplier's recommendations and estimates will be heavily influenced by the quality of information provided about the wind resource.

Cut-in

Another wind turbine characteristic that affects energy output is the cut-in wind speed—the wind speed at which the turbine begins to generate electricity. There will be no electricity produced when the wind speed is below the cut-in speed, though the machine may free-rotate at those lower speeds. Cut-in speeds typically vary from 7 to 10 mph. In areas like Dulce where winds are frequently light, it would be best to select a wind turbine with a low cut-in wind speed.

4.2.3.6 Sizing

Manufacturer quotes about small wind turbine power output only apply at a specific wind speed. A wind turbine that puts out 1000 watts at 18 mph but cuts out at 35 mph, may produce more energy over time than a wind turbine that is rated at 1000 watts at 28 mph and does not cut out until wind speeds exceed 50 mph. If the wind speeds are in the 10 to 20 mph range a high percentage of the time, this is the range where a wind turbine's power output should be compared to other models.

Peak power output of the wind turbine is nevertheless important for sizing of the balance of plant components. Peak power output will determine wire size and inverter capacity. Net metering would only be allowed if the total 'design capacity' of the wind turbine is 10 kW or less, so a larger wind turbine would force the customer into more onerous interconnection rules and a less certain power sales price for his power.

Under NM net metering rules, any electricity generated by a wind turbine during a month that is in excess of what the customer uses during that month is carried forward as a credit to the following month. The utility does not have to pay the customer for the excess generation until that customer leaves the system (NMPRC Rule 571.11.4). Even then, the rate paid for the excess generation will be the then-current avoided cost rates and not the retail rates. Therefore, when net metering, there is little value in installing a wind turbine sized to produce excess energy over and above the utility customer's use.

4.2.3.7 Wind turbine selection

It is a substantial challenge to design, manufacture, and install small wind turbines that are low in cost and yet rugged enough to withstand 20 to 30 years of operation in weather that is often severe. Small wind turbine technology development is both art and science. The qualities of a unit that makes it optimal for generating power in low wind speeds - long blades, light rotor weight, and low friction - also make it vulnerable to stress and over-speed in high winds. The true measure of a new design is often not known until several years of operation at dozens of sites. Therefore, it is important to select a wind turbine model with a long track record, from a manufacturer with a good reputation.

The physical characteristics of some representative turbines of various sizes are shown in Table 4.1 below.

Table 4.1 – Comparative Features of Small Wind Machines

Make or Vendor	Rating	Rotor Diameter	Cut-in wind speed	Weight
Whisper	3.2 kW	15 feet	7.1 mph	155 lb
Bergey	10 kW	23	7	1250
Jacobs	20 kW	31	8	1900
AOC	50 kW	49	10.2	

4.2.3.8 Economics

Table 4.2 below contains approximate energy generation and costs for several wind turbines of various sizes. At the current NORA Cooperative net-metering buy-back price of $0.077 per kWh (assuming NORA pays their avoided cost), a small wind turbine system will not pay for itself within its lifetime without substantial cost support from a government rebate program or tax advantages. The table assumes an average annual wind speed of 10 mph. The turbine yield at a specific site may be higher or lower, depending on the actual wind speed.

Table 4.2 – Comparative Economics of Wind Machines

Make or Vendor	Rating	Approximate annual energy @ 10 mph average at sea level	Estimated cost including installation	$/kW	Annual cost at 6%	$/kWh
Whisper	3.2 kW	3,800 kWh	$20,000	$6,250	$1,200	0.32
Bergey	10 kW	9,000 kWh	$46,000	$4,600	$2,760	0.30
Jacobs	20 kW	19,300 kWh	$50,00	$2,500	$3,000	0.16
AOC	50 kW	50,000 kWh	$135,000	$2,700	$8,100	0.16

The mean electricity use by residences in Dulce is about 5,100 kWh per year. Therefore, a 10 kW wind turbine should offset 100% of the electricity use by the average home and reduce electricity bills to the minimum monthly charge. The 20 or 50 kW machines would offset energy use by a larger home or small business, but requires considerably larger capital investment and aggregation of load. Larger wind turbines will also require the infrastructure to connect to the utility at higher voltages, such as the AOC's voltage of 480 volts.

4.2.3.9 Limitations

The systems described above are not intended to supply a home or business with electricity during a utility outage. To perform that function, additional and more sophisticated equipment would have to be in place to regulate power output of the system to match power needs, and to reconnect with the utility when the utility outage was cleared. If a power supply during utility outages is needed, a separate fuel-driven emergency generator is usually found to be more convenient and cost-effective.

4.2.3.10 Other considerations

Utility requirements

The local utility must always be contacted before connecting a generator to any system connected to the utility to address any contractual, insurance, safety or power quality concerns.

If a wind turbine of more than 10 kW is planned for a residential installation, New Mexico's net-metering rules will not apply and a special agreement with the utility will have to be negotiated under NMPRC Rule 570. Separate metering and protection systems are, and reinforcements of the electrical connection equipment may be required in order to ensure system safety. The pricing for the energy sold to the utility will be subject to PRC approval.

Local governmental approval

The construction of structures higher than 35 feet is restricted in many areas, so special approval from local community development authorities may be required.

Noise

Although modern turbines are quite noise-free, there are some conditions with certain models where noise can be an issue. The methods that the wind turbine uses to control speed in high winds, such as side furling, work because they disrupt the aerodynamics of the blades. However, this disruption can also cause noise. Fortunately, the noise is similar to other wind noises that are caused by structures and trees in high winds. Wind turbine noises are often masked by ambient noise.

Aesthetics

The main reason people can be persuaded to overlook the visual intrusion of a wind turbine is because the turbine is beneficial environmentally. People may object to a wind turbine's presence if that environmental benefit is not being exploited, such as when the turbine is broken down. Therefore, one way to reduce the likelihood of neighborly objections is to keep the wind turbine well-maintained and operating.

Lot size

A lot large enough to prevent damage to neighbor's property in the unlikely event of a tower collapse may be one criteria that local governmental officials look for when approving a wind turbine application. A 100 foot tall tower would require a one-acre square lot size.

Shadow / flicker

If the wind turbine's shadow falls on a neighbor's residence, it can create an annoying flicker. The condition is most noticeable at low sun angles in the morning and evening when shadows are long and may be cast on neighbor's windows. The condition is most pronounced with the larger turbines with slower rotational speeds and wide blades. The flicker effect from smaller turbines with high rotation speeds and narrow blades may not even be noticeable to most people.

Federal Aviation Administration

Towers under 200 feet in height normally do not have to be reported to the FAA or state aeronautical division, unless they are near an airport or other controlled air space such as a military range. It would be a good idea to contact the local FAA office and the airport manager if a small wind turbine installation is planned within about 5 miles of the Jicarilla Apache Nation airport.

5 Geothermal Energy

5.1 Introduction

Geothermal energy is a renewable energy resource that taps into the heat that is available from inside the Earth. There are many places around the world where good geothermal resources are available and accessible for development, including the Jicarilla Apache reservation. The resource can be developed to provide energy supply—using the Earth's heat in the place of systems that rely on fossil energy. In addition, the Earth's heat can be used as a demand-side resource, displacing a portion of end-use energy in direct applications, and as a way of making building heating and cooling systems work more efficiently (see discussion of ground-source heat pumps below).

As explained below, geothermal energy offers environmental benefits, and with good management, provides a virtually inexhaustible supply. Geothermal plants have high availability (greater than 95%), and operate around the clock and around the year. System costs are increasingly competitive with conventional energy resources, with costs ranging from 4 to 8 cents per kWh, depending on the resource.

Geothermal energy is a domestic energy source that can greatly contribute to the nation's energy mix. It is clean and available 24 hours a day. The United States has an estimated 2800 MW of geothermal installed capacity; worldwide, the figure is 8000 MW. The U.S. Geological Survey estimated in 1979 that the hydrothermal geothermal power potential in the United States was approximately 23,000 MW. In addition, thousands of installations are using geothermal energy for agriculture, aquaculture, district heating and cooling, and other direct uses. This estimate of geothermal potential could be even higher.

According to a 2006 study sponsored by MIT, entitled "The Future of Geothermal Energy," focused on Enhanced Geothermal Systems (EGS) (systems that force water into deep, dry rock formations for steam production),

> *Geothermal energy from EGS represents a large, indigenous resource that can provide baseload electric power and heat at a level that can have a major impact on the United States, while incurring minimal environmental impacts. With a reasonable investment in R&D, EGS could provide 100,000 MWe or more of cost competitive generating capacity in the*

next 50 years. Further, EGS provides a secure source of power for the long term that would help protect America against economic instabilities resulting from fuel price fluctuations or supply disruptions. Most of the key technical requirements to make EGS work economically over a wide area of the country are in effect, with remaining goals easily within reach. This achievement could provide performance verification at a commercial scale within a 10 to 15 year period nationwide.

Geothermal energy has environmental benefits. Electricity produced from geothermal resources in the United States prevents the emission of 22 million tons of carbon dioxide, 200,000 tons of sulfur dioxide, 80,000 tons of nitrogen oxides, and 110,000 tons of particulate matter every year compared to conventional coal-fired power plants. A geothermal binary power plant, operating with a closed system, emits virtually nothing to the atmosphere. Technologies have been developed to recycle minerals contained in geothermal fluid so that little or no disposal or emissions occur. Also, in many geothermal plants, the hot water extracted from the Earth is recycled back into the resource, thereby replenishing the resource and eliminating any discharge of the water.

Geothermal energy is efficient and reliable for baseload electricity production. The average geothermal power plant efficiently uses land space, requiring a total of only 400 square meters of land to produce 1,000 megawatts of power over a plant life of 30 years. By contrast, coal and nuclear plants require land for open-pit and other mining, and additional land to store and transport the fuel. In addition, the average geothermal power plant produces electricity 90% of the time, compared with 65% to 75% for coal- and nuclear-powered plants.

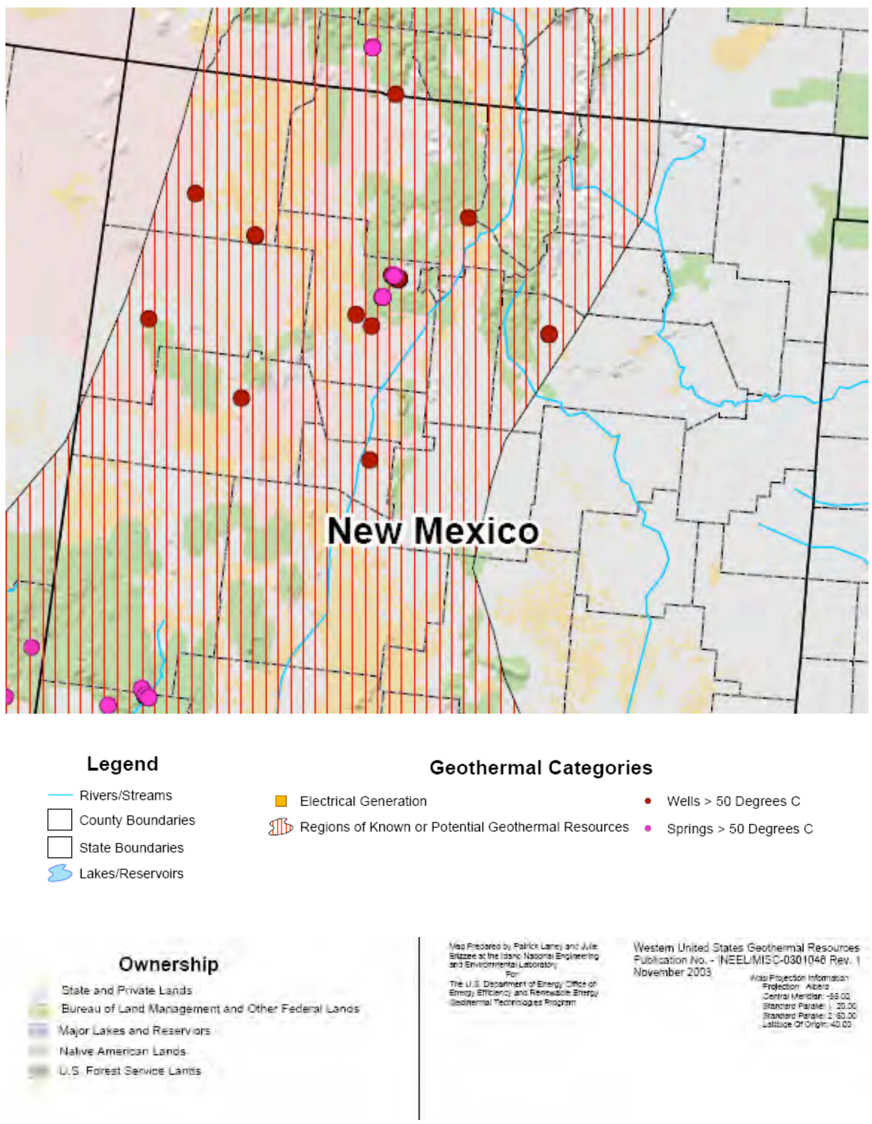
Although, by itself, geothermal energy will not replace fossil fuels as the major energy source in the United States, geothermal resources represent an important opportunity for development of clean geothermal power for local and regional customers. Geothermal resources also provide a significant opportunity for rural economic development through direct-use applications.

New Mexico’s highest temperature geothermal resource is the Baca Ranch area, now redesignated as the Valles Caldera National Preserve. Interest in the Baca location site peaked from 1972 through 1982, which culminated in a failed 50-MW commercial venture. Temperatures measured in exploration wells range from 225º-330º C at 200-3000 feet below the land surface. This is a well-characterized, high-temperature geothermal resource. Based on the pre-commercialization work of the 1980s and the advent of new technologies, the geothermal resource may be capable of producing 20 MW or more of electricity.

New Mexico has a very high potential for the direct use of geothermal energy—especially greenhouses— including the area north of Las Cruces at Radium Springs, and electrical energy replacement uses on the campus of New Mexico State University–Las Cruces. In addition, the Jemez Pueblo, the Acoma Pueblo lands west of Albuquerque, the Navajo Indian Reservation, the lands of the Jicarilla Apache tribe, and the Zia Pueblo lands have lower-temperature geothermal potential.

5.2 Resource

Figure 5.1 – Known Geothermal Resources in Northern New Mexico



5.3 Economic, Environmental and Social Benefits of Geothermal Use in New Mexico

In 2006, Liz Battocletti of Bob Lawrence & Associates, Inc. produced an introductory summary of the economic, environmental and social benefits of geothermal use in New Mexico. That report is reformatted and reprinted here in its entirety.

5.3.1 Introduction

Geothermal heat and water have been used in the Land of Enchantment for centuries. More than 10,000 years ago, North America Paleo-Indians used hot springs for cleansing, cooking, healing, and negotiating. Chief Geronimo himself bathed in the revitalizing waters. One of the first health spas was built in 1880 at Ojo Caliente Mineral Springs. Currently, geothermal heat or water is used in at least 30 hot springs—ranging from rustic to ritzy—across the state, and to also heat buildings, grow roses, and hatch young tilapia.

5.3.2 Economic benefits

Geothermal resources benefit New Mexico's economy in several ways. Geothermal saves energy and cuts operating costs. Geothermal businesses create jobs, foster commercial growth, promote rural development, attract tourists, and pay taxes. Some pay state and federal royalties as well.

New Mexico is home to two of the largest geothermal greenhouses in the United States, with a combined payroll of over $5 million and annual gross receipts of over $30 million. In business since 1977, Burgett Geothermal Greenhouse near Cotton City is the largest employer in Hidalgo County, and the largest geothermal greenhouse in the U.S. The 30- acre complex employs about 60 people, and ships 25 million roses a year to markets in the southwest. In addition to taxes, Burgett pays state and federal royalties. Burgett Greenhouse's annual cost savings by using geothermal heat compared to natural gas is about $1.8 million.

Established in 1987, Masson Geothermal Greenhouse in Radium Springs is the third largest geothermal greenhouse in the country, and the largest employer in northern Dona Ana County. The greenhouse employs 110 people and covers 18 acres. More than 30 kinds of potted plants including poinsettias are sold to markets from Arizona to the Midwest. Masson plans to expand to 40 acres in the future. Masson Greenhouse's annual cost savings by using geothermal heat compared to natural gas is about $790,000. In addition to greenhouses, geothermal water is used in aquaculture. Founded in Animas in 1995, AmeriCulture, Inc. is the largest Nile Tilapia fingerling producer in the country. Its geothermally heated, indoor facilities provide an optimum rearing environment for the fish, and minimize the possibility of introducing pathogens.

AmeriCulture's 10-12 full-time employees produce over 7 million fingerlings a year for shipment to domestic and international commercial producers. The low cost of geothermal energy makes it possible for AmeriCulture to compete with growers in Latin America. The company's annual cost savings by using geothermal heat compared to natural gas is about $240,000. AmeriCulture has plans to expand. It is working on a binary geothermal power plant design that, once built, would create 160 additional jobs in an onsite production and processing facility.

Spas and resorts heated with geothermal are scattered across New Mexico. The Jemez Springs Bath House has been around for approximately 100 years. About 20,000 people visit the bath house each year to soak in the therapeutic water. Eight attendants and 21 massage therapists work in the bath house.

With a staff of one, the Artesian Bath House and RV Park in Truth or Consequences has continuously operated since 1930. In 2005, over 6,600 people visited the bath house and 36-space RV park. Geothermal water from the Gila Hot Springs on the West Fork of the Gila River heats homes, greenhouses, and pools. Family owned and operated since 1940, the Gila Hot Springs Ranch boasts a natural hot springs jacuzzi and an RV park and campground. Gila Hot Springs is the site of the famous geothermally-heated Doc Campbell's Post Vacation Center built in 1963.

The numerous geothermal businesses across the state employ many people. Using a standard multiplier of 2.5, geothermal businesses create at least 540 direct, indirect, and induced jobs in New Mexico.

5.3.3 Environmental benefits

In addition to energy savings, geothermal energy prevents the emissions of greenhouse gases (GHG) and air pollutants, helping to keep New Mexico's air clean and its sky clear.

The business which use geothermal water for aquaculture, greenhouses, swimming pools, resorts, space heating, and hot water also prevent the emissions of air pollutants and GHG. If these businesses used electricity to generate the heat that geothermal water naturally contains, not only would most be unable to afford to stay in business, but they would emit at least 66,480 tons of carbon dioxide each year—the equivalent of 140,255 barrels of oil. In addition, they would emit 141 tons of nitrogen oxides and 98 tons of sulfur dioxides each year into New Mexico's air (see Table 1).

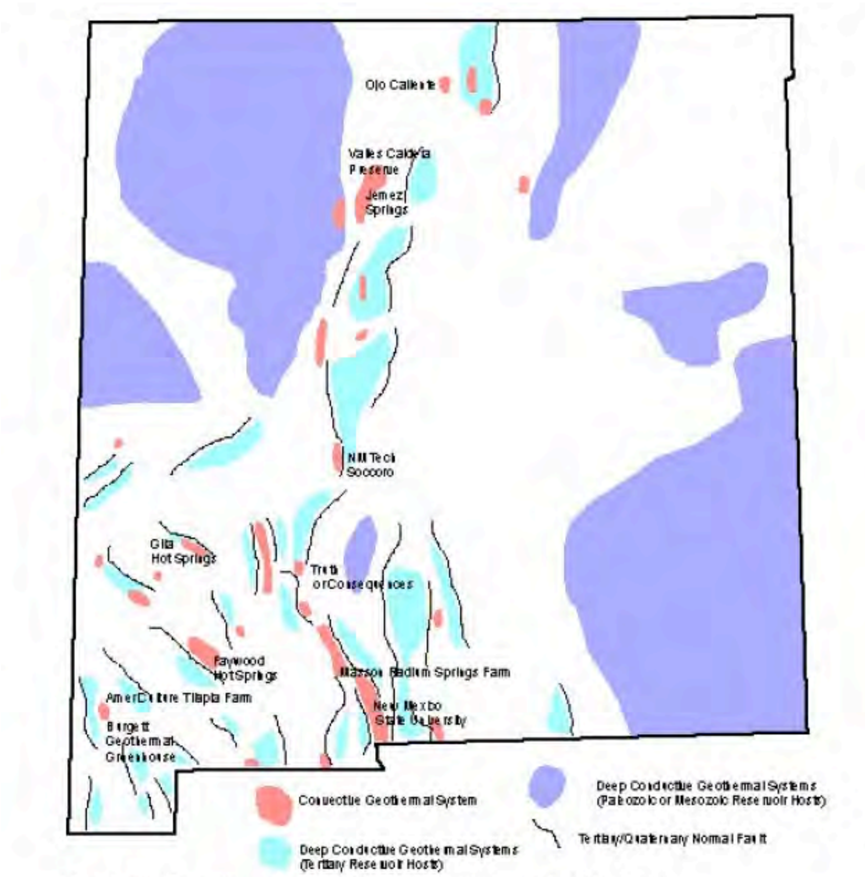
5.3.4 Social benefits

Social benefits are difficult to measure quantitatively. One key social benefit from geothermal energy's use in New Mexico, however, is improved quality of life through recreation. Geothermal provides many unique recreational opportunities enjoyed by tens of thousands of people each year, attracting tourists to the state.

5.3.5 Conclusion

While more than 360 thermal wells and springs are known to produce water with temperatures over 86ºF in 22 out of 33 New Mexico counties, the resource base is many magnitudes larger. All current use and nearly all the thermal well and springs tap shallow resources that are largely unexplored. An even larger resource base exists in deep reservoirs and aquifers beneath major sedimentary basins. The accessible and useable thermal energy in these resources is equivalent to more than 100 billion barrels of oil. The potential for geothermal to contribute to New Mexico economically, environmentally, and socially—even more than it already does—is great indeed.

Figure 5.2 – New Mexico Geothermal Resources



Geothermal resources in New Mexico. (Courtesy: Jim Witcher)

5.4 Geothermal Projects

The following sections on Geothermal Projects and Environmental and Regulatory Issues are taken from the "Geothermal Small Business Workbook," by Liz Battocletti, Bob Lawrence & Associates (May 2003). Citations from original are omitted.

Geothermal energy is heat (thermal) derived from the earth (geo). It is the thermal energy contained in the rock and fluid in the earth's crust. Geothermal resources come in all shapes, sizes, locations, and temperatures. A geothermal resource's temperature usually determines how it is used.

Table 5.1 – Potential Use Based on Geothermal Resource Temperature

RESOURCE TEMPERATURE	POTENTIAL USE
4ºC to 38ºC / 40ºF to 100ºF	Ground-source heat pumps
38ºC to 150ºC / 100ºF to 302ºF	Direct use
> 150ºC / 302ºF	Electricity generation

Highest temperature geothermal resources are generally used only for electric power generation. Current U.S. geothermal electric power generation totals approximately 2,800 MWe, equivalent to about four large nuclear power plants. Geothermal power plants range in size from a 350-kWe unit at the Wineagle plant to the proposed 187-MWe Salton Sea Unit 6 plant.

Lowest temperature geothermal resources are harnessed by ground-source heat pumps. Heat pumps transfer heat from the soil to the house in winter and from the house to the soil in summer.

Direct use projects have temperatures between those of heat pumps and electric power generation. They use heat in the water directly for a variety of purposes including: to grow flowers, raise fish, heat buildings, or dry vegetables. The current U.S. installed capacity of direct use systems totals 600 MWt (megawatt thermal), enough to heat 115,000 average-sized houses.

Geothermal projects can be "cascaded," e.g., use the same geothermal resource for multiple purposes, thereby increasing the operation's economics. Empire Foods in Nevada uses geothermal resources to generate electricity and dehydrate 26 million pounds of dried onion and garlic annually. Many spas and resorts use geothermal resources for heat, hot water, and pools, not necessarily in that order. And Liskey Farms in Oregon has used its geothermal resource to grow bedding plants and perennials, heat buildings and greenhouses, wash equipment, mix with chopped hay to feed calves, raise tropical fish, and water cattle.

There are five basic types of direct use geothermal projects:

1. Aquaculture,
2. Greenhouses,
3. Industrial and agricultural processes,
4. Resorts and spas, and
5. Space and district heating.

Direct-use systems are typically composed of three components:

1. A production facility – usually a well, to bring the hot water to the surface;
2. A mechanical system – piping, heat exchanger, controls, to deliver the heat to the space or process; and
3. A disposal system – injection well or storage pond, to receive the cooled geothermal fluid.

5.4.1 Direct use project types

5.4.1.1 Aquaculture

Aquaculture is "the production and sale of farm raised aquatic plants and animals." Geothermal aquaculture uses naturally occurring warm water to accelerate the growth of fish, shellfish, reptiles, amphibians, and aquatic plants. Rearing fish in controlled temperatures can boost growth rates by 50 to 100%, dramatically increasing the number of harvests possible each year. Aquaculture is a high potential development area for low-temperature geothermal resources.

Aqua-farmers in the United States grow alligators, bass, catfish, giant fresh water prawns, gold fish, koi, lobster, snails, sturgeon, tilapia, tropical fish, trout, turtles, and water lilies. There are currently 48 geothermal aquaculture operations in 11 Western states, including 2 in New Mexico.

Fish and other species can be raised in simple open air earthen ponds or sophisticated fiberglass tanks. In addition to the materials used, the cost of a geothermal aquaculture project depends on the size of the project, the species raised, and whether a well already exists. Well depths and drilling costs vary widely from $30-$200 per foot; most common well drilling costs are $50- $100/foot.

Ninety percent of direct use wells are less than 1,800 feet deep. Land cost is a significant portion of the total capital investment.

As one might suspect, water quality is extremely critical in aquaculture. Some of the water quality factors that can affect the growth of an aquaculture species are:

- Temperature,
- Dissolved oxygen,
- Nitrogenous wastes,
- pH,
- Alkalinity,
- Hardness,
- Carbon dioxide,
- Salinity,
- Chlorine, and
- Hydrogen sulfide.

The maximum pond area that can be developed depends on the maximum heat available from the resource. The resource temperature also determines what species can be raised. Each species has an optimum temperature at which it grows best. Temperature requirements and growth periods vary for aquaculture species. Growth periods to market vary, depending on the desired size of the fish.

5.4.1.2 Greenhouses

Greenhouse heating is one of the most common uses of geothermal resources. Because of the significant heating requirements of greenhouses and their ability to use very low-temperature fluids, they are a natural application. A wide variety of plants are grown in geothermal greenhouses including tree seedlings; roses, carnations, lilies, and other flowers; tomatoes, lettuce, cucumbers, and other vegetables (hydroponic and otherwise); poinsettias; potted plants; and flower and vegetable bedding plants.

Commercial greenhouses offer investment and career possibilities. Typical barriers to entry are relatively low, and net investment levels are not prohibitive. The industry is also highly fragmented, without any dominant leaders in terms of size or net sales. Markets appear to be plentiful throughout the country, and metropolitan markets are readily served from outlying rural areas.

There are currently 41 geothermal greenhouse operations in nine Western states, including 5 in New Mexico.

The first step in designing a greenhouse is to determine the heating requirements which is primarily a function of the temperature difference between the inside and the outside, and construction materials. Six different geothermal heating systems may be used in greenhouses:

- Finned pipe
- Standard unit heaters
- Low-temperature unit heaters
- Fan coil units
- Soil heating
- Bare tube

For a small “backyard” greenhouse, the simplest heating system is the hot water unit heater. Unit heaters are a practical method of greenhouse heating at supply water temperatures down to 60-65ºC (140-150ºF).

Greenhouses can be made of glass, plastic film, fiberglass or rigid plastics, or a combination of materials. Glass greenhouses are the most expensive to build because of the glazing material and the need for a stronger framework to support the glass. Glass offers the highest light quality but the lowest energy efficiency.

The heating system also depends on the grower’s preference and the type of crop or possible disease problems. Roses and mums need closely controlled humidity and air circulation; tropical and subtropical plants need high humidity and high soil temperatures.

Capital costs vary by project size, location, material used, and whether a well currently exists. Northern climates have higher costs due to the need for additional thermal curtains. Commercial greenhouses range from 1 to 30 acres in size (1 acre = 43,560 sq. ft.). Total greenhouse costs, including the greenhouse and operating equipment, are $12.84-$16.12/sq. ft. of greenhouse, with an average cost of $14.32/sq. ft. A “backyard”-1,000 sq. ft. greenhouse would cost approximately $14,320. A one-acre greenhouse would cost about $624,000, excluding economies of scale. Of the total, construction costs alone are $8.26-9.11/sq. ft. with an average of $8.42/sq. ft. Land cost is a significant portion of the total capital investment.

Most greenhouse operators estimate that using geothermal resources instead of traditional energy sources saves about 80% of fuel costs—about 5% to 8% of total operating costs. The relatively rural location of most geothermal resources also offers advantages, including clean air, few disease problems, clean water, a stable workforce, and, often, low taxes.

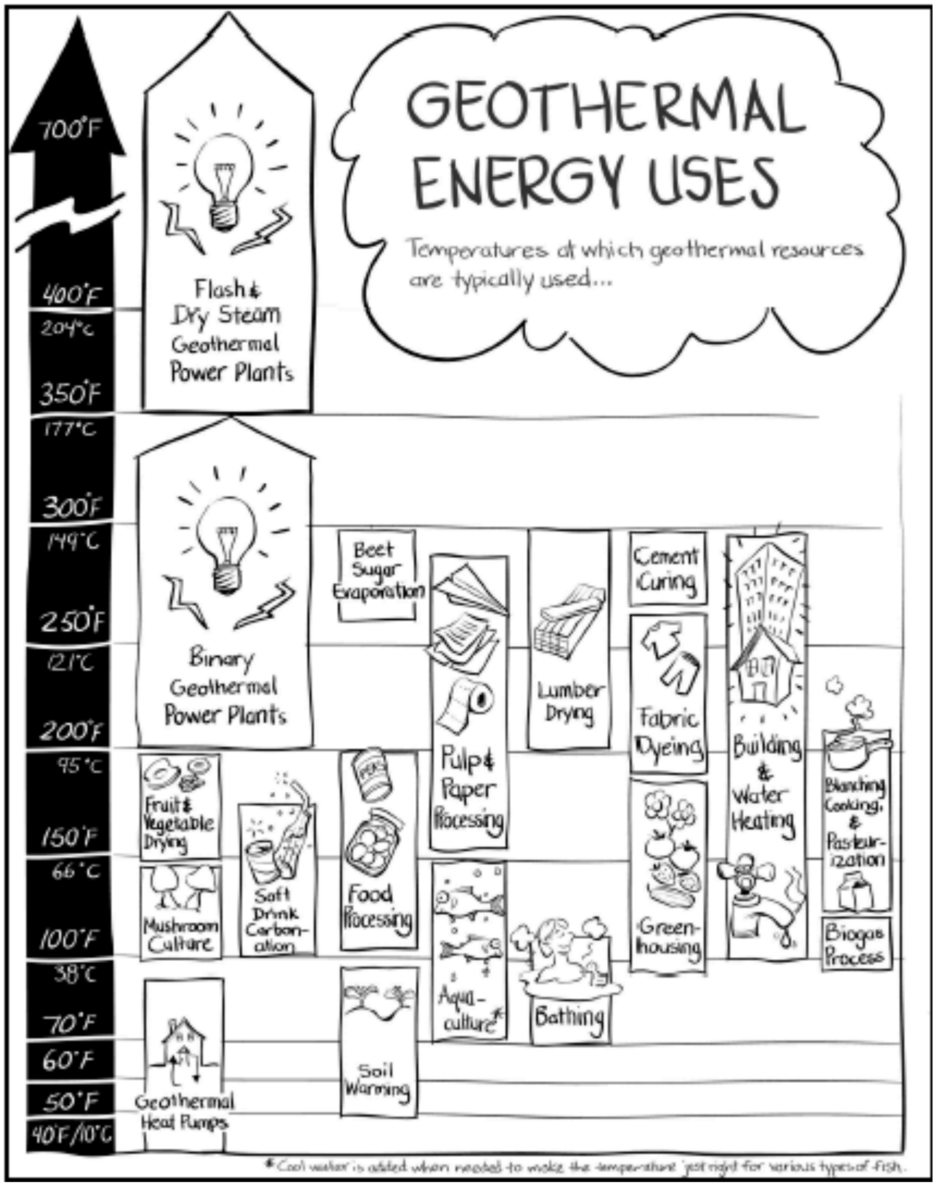
5.4.1.3 Industrial or agricultural processes

Geothermal fluid can be used for a wide range of industrial and agricultural processes. Industrial applications include food dehydration, laundries, gold mining, and milk pasteurization. Dehydration of vegetables and fruits is the most common industrial use of geothermal energy.

A new development in the use of geothermal fluids is the enhanced heap leaching of precious metals in Nevada by applying heat to the cyanide process. Using geothermal energy increases the efficiency of the process and extends the production into the winter months.

The “Geothermal Energy Uses” illustration at Figure 5.3 on the following page graphically shows the wide range of the temperatures at which geothermal resources are typically used for many industrial and agricultural processes, e.g., beet sugar evaporation, pulp and paper processing, lumber drying, and soil warming.

Figure 5.3 – Geothermal Energy Uses



5.4.1.4 Resorts and spas

People have enjoyed soaking in warm geothermal water and mineral waters for centuries. The earliest commercial use of geothermal energy was for swimming pools and spas. Based on archeological finds in Asia, mineral water has been used for bathing since the Bronze Age, about 5000 years ago. The Greeks, Turks, and Romans were famous for their spa development.

Closer to home, Native Americans considered hot springs sacred; every major hot spring in the U.S. has some record of use by the Indians. Early European settlers found and used these natural hot springs. Realizing their commercial value, they developed many into spas after the European tradition. Most recently, the health and fitness craze has made spas a high growth industry. The most traditional type of health spa is the geothermal spa, featuring baths and pools of natural hot mineral waters.

Spa design depends on the local culture, the unique character of the location, and what the developer is trying to achieve in terms of atmosphere, service, and type of clientele. There are currently 236 geothermal resorts and spas in 14 Western states, including 17 in New Mexico.

5.4.1.5 Space and district heating

More than 120 operations, with hundreds of individual systems at some sites, are using geothermal energy for district and space heating in the United States.

Space and district heating are very different animals. Space heating systems use one well per structure. Geothermal district heating (GDH) systems distribute hydrothermal water from one or more geothermal wells to several houses and buildings, or blocks of buildings. In both systems, the geothermal production well and distribution piping replace the fossil-fuel-burning heat source of the traditional heating system. Hot water, rather than steam, is the heat transfer medium.

Geothermal space and district heating systems are widely used across the western United States. There are currently 121 geothermal district and space heating sites in 13 western states including 6 in New Mexico.

Space heating

In space heating, one well provides heat, hot water, or both to one building. Space heating of an individual building is fairly easy to justify economically, provided the heating load is large enough and there is a geothermal resource.

The most common type of space heating system used in homes in the U.S. is forced air. In most cases, the air is heated by a fossil fuel furnace or heat pump. Adapting an existing system to use geothermal heat, or designing a system for new construction, is a straightforward process. The system consists of a finned coil, normally located in the supply air duct, a motorized valve to control the water flow in response to a signal from a thermostat, piping to deliver the water to and from the coil, and a few associated plumbing and electrical components.

Domestic hot water heating often requires higher temperature water than space heating. This is because heat is being transferred to a 49ºC (120ºF) or greater sink rather than the 21ºC (70ºF) air in a space heating application.

District heating

Most GDH system development has occurred since the late 1970s; approximately 90% of current systems started-up in this period. The Boise Warm Springs Water District, however, began operating in the 1890s, and the system serving the Oregon Institute of Technology campus was constructed in 1963. Many of the newer district systems, e.g., San Bernardino, were developed with DOE assistance in the early 1980s.

GDH systems typically have six subsystems. All but items 1 and 6 differ from conventionally fueled heating systems.

1. Production facilities,
2. Central plants (in closed-distribution systems only),
3. Distribution,
4. Customer connections,
5. Metering, and
6. Disposal.

Wells used for geothermal district heating systems vary in depth, from 275 feet at Pagosa Springs, to 3,030 feet in Boise. They also range in temperature, from 59ºC to 103ºC (138ºF to 218ºF).

Fuels costs for geothermal systems consist only of the electrical costs of operating the production well pumps. Once operational, GDH systems can save consumers 30% to 50% per year of the cost of natural gas. The major obstacle to developing a GDH system is the cost of the piping necessary to deliver the heat to the customers and, the economics for the customer. The issue is the cost between the heat source and the customer.

An important consideration in GDH projects is the thermal load density, or the heat demand divided by the ground area of the district. A high heat density is required to make district heating economically feasible because the distribution network that transports the hot water to the consumers is expensive.

The economics of converting to a GDH system vary depending on the size of the building to be connected, and the existing heating system. In large buildings (>50,000 sq. ft.), the economics of connecting to GDH system are often positive.

Generally, small buildings (10,000 sq. ft.) use heating systems that are not hot water based and must be retrofitted. An automotive repair shop with three unit heaters would have a retrofit cost of about $15,000. A small office with two roof top heat pumps would incur a retrofit cost of approximately $10,000. The economics of retrofitting may not provide sufficient incentive to the owner to connect to the GDH system.

In the smallest buildings (< 5,000 sq. ft.), connecting to a GDH system may make economic sense if the GDH system offers heating costs that are substantially lower (40% to 50%), the building has high energy use, and the owner is currently using a high cost fuel (e.g., electric resistance or propane).

While most existing GDH systems charge rates which are lower than the most commonly used competing fuels—some as little as 70% of natural gas—the prospects for competing with natural gas appear unfavorable in all cases. Clearly incentives beyond energy cost savings are required to entice small buildings to connect to GDH systems.

Geothermal energy may also be used for cooling through the absorption cycle process. The equipment, however, is very expensive relative to electric chillers. A high cooling requirement and high electricity rates are needed to make it economically feasible.

5.4.2 Small-scale power generation (1 MWe or less)

The hottest geothermal resources may be used to generate electricity. Unlike fossil fuel power plants, no fuel is burned in a geothermal power plant. Fuel is "free."

There are five types of geothermal power plants:

1. Dry Steam – Steam from the resource drives the turbine directly. The Geysers in northern California is the largest known dry steam field in the world, and has been producing electricity since 1960. Dry steam resources are very rare.

2. Flashed Steam – Hot water from wells passes through separators where it flashes (explosively boils) to steam. The force of the steam spins the turbine generator. A plant can be single or double flash.
3. Binary – The heat of the geothermal water is transferred via a heat exchanger to a second (binary) liquid in an adjacent loop. The second "working" fluid boils to vapor which in turn powers the turbine generator. Binary plants use lower temperature resources (38-149ºC or 100-300ºF). Binary plants are well suited for small modular units in the 1-3 MWe range.
4. Hybrid – A hybrid plant uses a combination of technologies, e.g., Single Flash Binary Plant. Hybrid plants have a higher overall efficiency than plants that use just one technology.
5. Kalina – A Kalina cycle plant uses an ammonia-water mixture. Ammonia's lower boiling point allows additional energy to be obtained on the condenser side of the steam turbine, possibly increasing output by 20-30%. The Kalina cycle is in the prototype stage.

Geothermal power plants generate approximately 2,800 MW of electricity in the United States, primarily from plants with an installed capacity of 5 MW or more.

Six plants in the United States are smaller than 5 MW. Only one plant currently in operation has an installed capacity of 1 MWe or less—the 700-kWe Wineagle plant in California.

A geothermal power plant costs more up-front than a fossil fuel-powered plant due to the risks and costs associated with exploring and proving the resource. Small plants cost more per kWe than their larger counterparts. The initial cost for a field and small power plant is about $3,000-5,000/installed kWe, compared to $1,500-$2,500/kWe for a larger plant, depending on the resource temperature and chemistry. Operating and maintenance (O&M) costs range from 1.5-2.5¢/kWh, depending on the contract price for the electricity. In general, the cooler the geothermal resource and the smaller the installed capacity of the plant, the more expensive the project. The following table illustrates capital and O&M costs for small binary geothermal plants utilizing various resource temperatures.

Table 5.2 - Capital and O&M Costs for Small Binary Geothermal Plants

Net Power (kW)	Resource Temperatue, °F			Total O&M Cost ($/yr)
	212	248	284	
	Capital Cost, $/kW			
100	$2,786	$2,429	$2,215	$21,010
200	$2,572	$2,242	$2,044	$27,115
500	$2,357	$2,055	$1,874	$33,446
1,000	$2,143	$1,868	$1,704	$48,400

A 250-kWe geothermal power plant would not be a freestanding business. It could be profitable, however, if power generation is linked to a direct use, e.g., aquaculture, greenhouse, dehydration, etc., that has a constant and reliable cash flow. The approximate cost of a 250 kWe-plant is $350,000-$450,000.

A stand-alone 1-MWe plant could be economically viable if there is potential for commercial sale of the electricity produced, and it can be sold at a competitive rate. The approximate cost of a 1 MWe-plant is $3-$4 million. Assuming the plant can sell power to the grid at 5¢/kWh and has a 90% capacity, annual revenues would be about $450,000.

Small-scale geothermal power plants have the potential for widespread application, including off-grid and distributed energy, but achieving cost effectiveness is a challenge. Under off-grid generation, an "island" of generation and energy service to a limited power distribution system can be provided. In an off-grid system, the need for expensive transmission and interconnections to the larger grid is eliminated. Also, diesel generation, generally used for remote power installations, is more expensive than conventional utility generation.

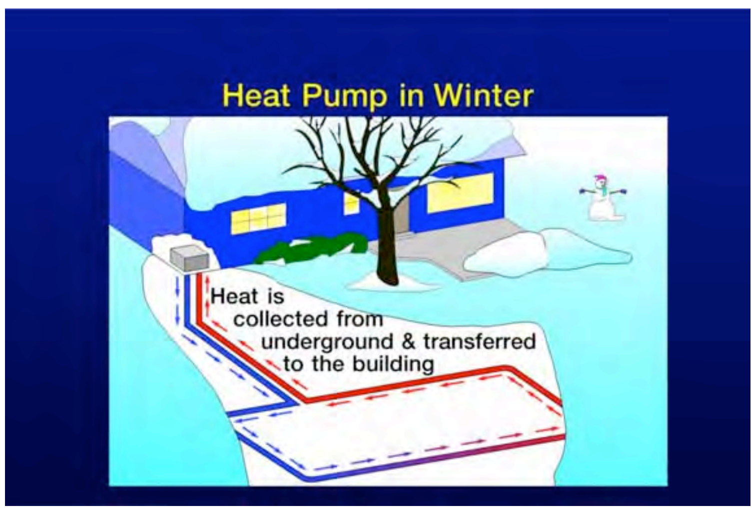
Geothermal heat pump systems

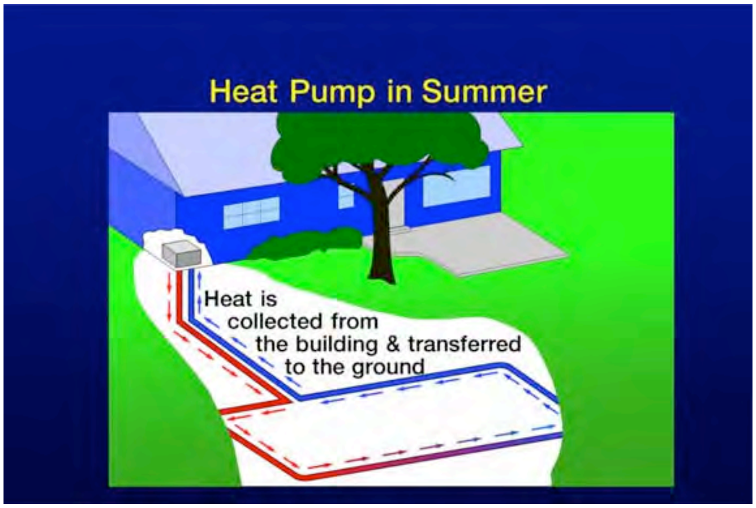
An excellent use for the Earth's heat is as a source or sink for heat. Geothermal, or Ground-Source Heat Pump ("GHP") systems draw heat from the Earth when heating is needed, and reject heat to the ground when cooling is needed. GHP systems can be sized for single family homes, but have their best economics as part of the heating and cooling system for large commercial and institutional buildings. These systems take advantage of the fact that the ground is at a near-constant temperature year round. That means the earth is cooler than the air in summer, and warmer than the air in the winter. The basic GHP system is simply a heat exchanger connected to a system of pipes that are buried in the ground. Fluid is pumped through the tubes and heat is exchanged through contact of the pipe walls with the surrounding ground.

Figure 5.4 - Commercial Building GHP System

Even though the flow of heat or cooling is opposite in winter than in summer, a single system can provide both heating and cooling through a simple reversing of flow.

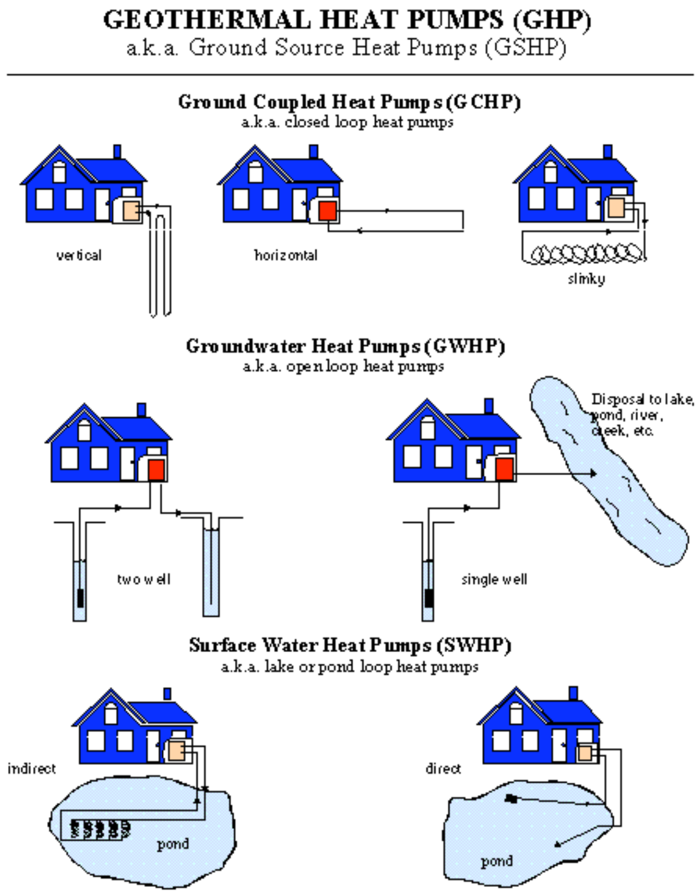
Figure 5.5 - Heat Pump in Winter and Summer Operation





GHP systems offer several benefits that make them attractive from an economic, energy services, and environmental perspective. The systems are highly energy efficient. The heat gain or rejection system uses far fewer moving parts than conventional systems, and is therefore more reliable. GHP systems are proven in hundreds of applications around the country, in all kinds of climates. System life is typically from 15 to 25 years before major maintenance is required. Typical systems can provide 70% of a building's heating and cooling systems from the Earth's own heat—a renewable source of energy. GHP systems do cost more than conventional systems, but pay for themselves through savings in electricity or fuel costs as well as maintenance and equipment replacement cost savings. The piping loop can be configured in a wide variety of ways to adapt to local conditions. The pipe can even be installed in water systems, like wells or ponds.

Figure 5.6 - Configurations for GHP Systems



5.5 Regulatory and Environmental Issues

Geothermal resources are related to water, gas, and minerals; to both the surface and subsurface estates; and to both water rights and mineral titles. Where the resource is located—whether it is located on public or private, Federal or state owned land—determines what regulations govern its use. (While these issues may not directly apply to Jicarilla Apache land, they are relevant if the Nation decides to pursue projects off the reservation.)

The Bureau of Land Management (BLM), pursuant to the Geothermal Steam Act, of 1970, has jurisdiction for geothermal leasing and permitting on Federal lands. This authority covers about 570 million acres of BLM land, National Forest System lands (with the concurrence of the Forest Service), and other Federal lands, as well as private lands where the mineral rights have been retained by the Federal Government. Federal lands located in a Known Geothermal Resource Area (KGRA) are leased competitively, and any Federal lands not located in KGRAs are leased noncompetitively.

Resources located on non-Federal lands, and utilized for direct use are governed by local permitting and land use ordinances, groundwater law, and the availability of water rights.

Various federal, state, and local laws, and regulations directly and indirectly affect geothermal projects. Many are focused more towards electrical generation projects than to direct use projects. However, the appropriate regulating agencies must be contacted to determine what requirements may apply to a specific project.

The main environmental factors to be considered during the exploration, development, and operation of a direct use geothermal project are:

- Airborne emissions,
- Water contamination,
- Land subsidence,
- Induced seismicity,
- Noise,
- Water availability,
- Solid waste,
- Land use,
- Vegetation and wildlife, and
- Economic and cultural factors.

The degree to which geothermal development affects the environment is, in most cases, proportional to the scale of the development. Direct use projects are often designed to be closed-loop. Low- or moderate-temperature geothermal fluids are circulated through a heat exchanger or heat pump (or flow naturally around down-hole heat exchangers), in a small area with limited or no emissions to the atmosphere. The spent geothermal fluids are then injected into or near the production aquifer, or discharged into nearby surface drainage and waterways or both.

Representative project environmental benefits

Geothermal technologies offer significant environmental benefits because they generate useful energy that displaces use of more polluting fossil fuels. Every geothermal project is unique, of course.

Table 5.3 – Greenhouse Gas and Air Pollutant Emissions Offset by Geothermal Businesses in New Mexico.

Site	Location	Application	*Annual Energy Use*		*Annual Emissions Offset (lbs)*		
			Btu billion	Equivalent kWh	Nitrogen oxides	Sulfur dioxide	Carbon dioxide
AmeriCulture, Inc.	Animas	Aquaculture	11	3,223,781	10,606	7,373	5,003,656
Artesian Bath House and RV Park	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Burgett Geothermal Greenhouses	Animas	Greenhouse	184	53,925,064	177,402	123,324	83,697,519
Charles Motel & Spa	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Faywood Hot Springs	Faywood	Resort/Pool	1	293,071	964	670	454,878
Fire Water Lodge Bed & Breakfast	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Geronimo Springs Museum	Truth or Consequences	Space Heating	1	293,071	964	670	454,878
Giggling Star	Jemez Springs	Resort/Pool	1	293,071	964	670	454,878
Gila Hot Springs Ranch.	Silver City	Space Heating	2.5	732,678	2,410	1,676	1,137,195
Hay-Yo-Kay Hot Springs and Spa	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Hot Springs Soaking Pools	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Indian Springs	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Jemez Springs	Jemez Springs	Space Heating	1	293,071	964	670	454,878
Jemez Springs Bath House	Jemez Springs	Resort/Pool	1	293,071	964	670	454,878
Marshall Hot Springs	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Masson Radium Springs Farm	Radium Springs	Greenhouse	76.8	22,507,853	74,046	51,474	34,934,617
Ojo Caliente Resort	Ojo Caliente	Resort/Pool	1	293,071	964	670	454,878
Radium Hot Springs Inn	Radium Springs	Resort/Pool	1	293,071	964	670	454,878
River Bend Hot Springs	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Senior Citizens Center	Truth or Consequences	Space Heating	1	293,071	964	670	454,878
Sierra Grande Lodge & Spa	Truth or Consequences	Resort/Pool	1	293,071	964	670	454,878
Wilderness Lodge and Hot Springs	Silver City	Resort/Pool	1	293,071	964	670	454,878
		Totals	**292.3**	**85,664,654**	**281,816**	**195,907**	**132,960,791**
					141	**98**	**66,480**
					Tons/year		

Note: Energy use is estimated.

6 Biomass Power & Heat from Wood Pellets

6.1 Introduction

Historically, the Jicarilla Apache Nation forestry program has been designed to sell the right to harvest timber. Proceeds were used to assist economic development within the natural resources division. In more recent years, the tribal council adopted by resolution a timber plan to sell timber. Under this plan, the forestry program harvested viable logs for production and shipped them off the reservation to a mill located in Espanola, New Mexico. Since the closure of this mill in 2002, sales have decreased from million board feet to a few thousand board feet.

6.2 Forest Inventory

According to the Jicarilla Apache Nation Forestry Branch inventory of April 2006, the Nation has approximately 19,866 acres of potential harvest area on the Reservation. These numbers are based on harvest trees 5-10 inches in diameter, yielding an average of 7.5 tons per acre. This 5 to 10 inch diameter component is the standard component currently under-utilized due to current market conditions and area saw mill configurations. For the remaining four years in the harvest schedule this would generate approximately 148,995 tons of wood fiber. As a result of harvest activities, another 2.5 tons per acre would be generated in the form of logging slash. A conservative estimate of the amount of slash generated from timber sales is 49,665 tons over the next four years. Consequently, the potential availability for wood fiber would be a total of 541,404 tons. Although the Forestry Branch plans to offer for sale the above mentioned 19,866 harvest acres over the next four years, there is no guarantee that any of these timber sales will be executed. Due to poor market conditions and the lack of saw mill capacity in the southwest, it is expected that only a portion of the current harvest schedule will be accomplished. Therefore, not all of the available wood fiber will be generated unless market conditions improve.

6.3 Biomass Power

According to a study conducted by the State of Oregon, a 5-MW biomass power plant would use an estimated 123,000 green tons of fuel per year and would create an estimated 16 new jobs at the plant with payroll and benefits equal to $600,000. A 25-MW biomass power plant would use an estimated 430,000 green tons of biomass per year, but would only require one additional employee at the plant, for a total of 17 employees. Total payroll and benefits for the 25-MW biomass power plant would equal $641,250.

In addition to jobs at the plant, the development of a biomass power facility would stimulate employment in the fuel supply and delivery sectors (fuel procurement). The 5-MW plant would employ approximately 18 people in fuel procurement. A 25-MW plant would employ 54 people in fuel procurement.

Therefore, a 5-MW plant would support 34 new jobs, including plant operations and fuel procurement. A 25-MW plant would support 71 new jobs.

However, the estimate of available feedstock on the Jicarilla Apache Reservation is inadequate to fully support even a 5-MW facility. As a result the only practical option available to the Tribe is to cooperate in the supply of fuel to a biomass power facility. The Utility Authority has been exploring this alternative.

6.4 Biomass for Heat – Wood Pellets for Household and Building Stoves

The Nation has an alternative for use of biomass material that could complement a lumber mill initiative and create affordable building heat on the reservation. The use of biomass material for heat therefore offers a potential opportunity to support forestry operations and, at the same time, create a clean heat source for homes and added revenues. The most common alternative approach in heating a home with fossil fuels or electricity is to install wood pellet stoves. A program to offer and install wood stoves that utilize pellet fuel in homes and other buildings on the reservation could have considerable advantages:

- Reduces dependence on oil and gas; sustainable source of fuel.
- Pellet fuel cost is not dictated by world events; therefore, cost is more affordable and predictable.
- Since pellet stove emissions are so low, they can be burned in most areas even those with burning restrictions. Pellet fuel has been proven to provide the cleanest burn of any solid fuel.

- Only minimal clearance is needed for appliance installation. Because of the near total combustion (around 98.5%) pellet stoves produce virtually no creosote. The resulting lack of chimney fouling allows installation of a pellet stove by direct vent without a chimney.
- A 40-pound bag of New Mexico Wood Pellets produces only 3 ounces of ash; this reduces waste destined for landfills and associated costs.
- One ton of wood pellets have the heat value of about one and a half cords of wood, and stack easily in one third of the space. This makes it possible to easily store fuel for the entire season.
- Use of waste and slash materials from forest and lumber mill activities would improve the economics of those activities.

6.5 Pellet Operation

The most common residential pellets are made from sawdust and ground wood chips. Pellet mills across the country receive, sort, grind, dry, compress, and bag wood and other biomass waste products into a conveniently handled fuel. Pellets are usually packaged in forty pound bags and sold by the bag or by the ton. The normal dimensions of a pellet are one and half inch in length and a quarter inch in diameter. There are two grades of pellets: standard and premium. Standard grade pellet fuel is usually derived from materials that result in more residual ash, such as sawdust containing tree bark. The bark adds more impurities with ash content up to 3% residue in the stove. Premium grade pellet fuel has no tree bark and often the ash content is .7% which is significantly lower in the stove. Premium pellets make up 95% of current pellet production and can be burned in stoves calling for either standard or premium fuel. Some stoves are built to hold more ash content depending on the ash drawer, fuel feed and grate design. The selling price of pellets currently ranges anywhere from $120 – 200 per ton and averages $150 per ton. Smaller quantities are also available from 20lb -100lb. Package prices vary depending on region.

6.6 Pellet Stoves

Pellet stoves are categorized according to their method of delivering fuel. Top feed stoves deliver pellets from a tube or chute above the fire. Bottom feed stoves deliver pellets from behind or besides the burn pot, directly to the fire. Pellet feed mechanisms also vary. The three types of feed mechanisms are: automatic fuel deliver, freestanding stove, and fireplace insert. The automatic fuel delivery from the hopper frees the operator from frequent attention and loading, while providing clean burns and desired comfort level. Freestanding stoves are placed on a non-combustible floor protector, on legs designed to be installed in most homes. Fireplace inserts are similar in design but they insert into any fireplace. The typical characteristics of today's stove include a full automatic on/off thermostat, oversized ash pans, and large pellet hoppers. Some models may have a fire starter or ignition, heat exchanges, and a room thermostat. Stove prices range from $1,500 to $2,500, depending on options selected.

6.7 Pelletizer Plant Considerations

A number of factors must be considered in determining whether the Nation can and should develop and operate a pelletizer plant. A comprehensive and detailed review should be undertaken before reaching a final decision on whether to proceed with the concept. Key factors that should be addressed include:

6.7.1 Volume of available raw material

Pelletizer plant economics depend on the size of the facility. Sufficient feedstocks must be available to support economic operation of the plant.

6.7.2 Feedstock quality

A study of the feedstock quality is necessary to determine the ultimate pellet quality and cost to produce pellets.

6.7.3 Potential market

The pelletizer plant economics also dictate a minimum economic production volume, which in turn implies a sufficient market to support the investment. A detailed study of the market on the reservation and in neighboring communities is a prerequisite of the investment decision.

6.7.4 Plant site

A site, preferably on the Reservation must be identified for construction of the pelletizer plant. Site assessment and development will be required, implying another key element of study.

6.7.5 Additional equipment

The pelletizer plant must be served by additional activities related to production of the pellets, including gathering and transportation, feedstock preparation and storage, product packaging, product storage and delivery, and operating support for customers. These supporting activities will generate additional jobs, but will require investment and development.

6.7.6 Types and cost of stoves, maintenance

The pellet stove that ultimately operates in the customers' homes will represent a significant investment. The stoves will also require installation, operating, and maintenance support. The Utility Authority or other entity could undertake this function, but a plan must be developed for sales, financing, and support.

6.7.7 Workforce training and availability

An assessment of supporting labor requirements will be required to ensure the plant and related operations can be sustainable.

7 Biodiesel

Biodiesel is a transportation or generator fuel that is made from agricultural or animal materials, such as soy oil or chicken tallow. The Jicarilla Apache Nation could make use of this fuel to reduce emissions associated with use of fossil fuels. However, the Nation does not have economical resources for production of the fuel. This brief introduction to biodiesel was taken directly from materials authored by Renewable Energy Partners of New Mexico.

7.1 Introduction

In 1890, Rudolf Diesel, the inventor of the highly efficient engine that bears his name, wanted to empower farmers by affording them an alternative to high-priced petroleum fuels. So, he designed his engine to run on hemp and peanut oil.

Tests have demonstrated biodiesel's performance to be virtually the same as standard diesel. Like ethanol, biodiesel is a renewable fuel and can be produced domestically. Domestic production keeps U.S. dollars from flowing out of the country, reduces the nation's dependency on foreign oil, and strengthens the agricultural economy of the U.S.

Biodiesel is commonly made from a wide variety of vegetable and tree oils, animal fats and/or used cooking oils. These oils are blended with alcohol, (usually methanol or ethanol) and a catalytic agent such as sodium hydroxide. The resulting chemical reaction produces an ester and glycerin. Glycerin is a substance commonly used in soaps and other consumer products.

Table 7.1 - Comparison of Energy Yield from One Btu of Fossil Energy Used

Fuel	*Energy Yield	Net Energy (loss) or gain
Gasoline	0.74	(26 percent)
Diesel	0.83	(17 percent)
Ethanol	1.34	34 percent (corn ethanol)
Biodiesel	3.20	220 percent
* Yield in liquid fuel BTUs per Btu of fossil fuel energy dedicated		
Source: USDA, Economic Research Service Report number 721		

7.2 Production of Biodiesel

Production of biodiesel is a lower energy use and less complex process than the production of corn-based ethanol. Soy-based biodiesel has a positive energy balance of 3:1. That is, its combustion results in three times as much energy as is required to convert it from its feedstock. Biodiesel blends are competitive with other alternative fuels on a life-cycle basis. And, biodiesel is readily biodegradable, nontoxic and sulfur-free. Use of biodiesel quiets the engine, can eliminate black cloud emissions, reduces odor and improves engine life. The greatest benefits are derived from using pure biodiesel (B100). Biodiesel is the only alternative fuel to have passed the rigorous health effects testing of the EPA Clean Air Act. Like ethanol, biodiesel is available in a variety of blends, with B20 (20% biodiesel/80% petroleum diesel) the most common. B20 fuel is generally priced 5 to 20 cents more per gallon than regular diesel.

Table 7.2 - Biodiesel Air Pollution Reduction as Compared with Petroleum Diesel (US Department of Energy)

Emission	B20	B100
Carbon Dioxide	-15%	-78%
Carbon Monoxide	-12.6	-48%
Unburned hydrocarbons	-20%	-67%
Particulates	-12.0%	-47.4%
Nitrous Oxides	+1.2%	+5.8%
Air toxics	-12%–-20%	-60%– -90%
Mutagenicity	-20%	-89%– -90%

7.3 Uses of Biodiesel

B100, or pure biodiesel, can be used anywhere standard diesel is used except during cold weather. In cold weather, biodiesel thickens more than diesel fuel and special heating systems are required. Because biodiesel is a powerful solvent, equipment made before 1993 may have rubber seals in fuel pumps and fuel systems that could fail if B100 is used. When using biodiesel in an engine, rubber seals used in the fuel delivery system should be replaced with Viton™ or other non-rubber seals.

B20 or B35 biodiesel can be used in any diesel engine, even in old engines, with no changes. However, since biodiesel cleans the fuel tank and fuel system, the fuel filter should be replaced shortly after switching to biodiesel. It is best to keep several spare fuel filters handy during the first few weeks after changing fuels. There are fewer cold weather problems with lesser blends of biodiesel (B20 or B35), and biodiesel mixes well with petroleum diesel fuel and stays blended even in the presence of water. Diesel fuel/biodiesel blends have superior lubricity that reduces wear and tear on the engine and prolongs engine and component life. The car manufacturer should be consulted to that use of a particular biodiesel blend does not void the engine warranty.

7.4 Greenhouse Gas Benefits of Biodiesel

Each year, soybeans and other plants that produce oils used for making biodiesel draw carbon dioxide (CO2) from the atmosphere to build stems, leaves, seeds (which contain the oil) and roots. At the end of the year, the oil used to make biodiesel is burned and the leftover plant material decomposes, returning the carbon from the fuel and plant matter to the atmosphere as CO2. This recycling of carbon from CO2 in the atmosphere, to carbon in plant material, and back to the atmosphere results in no accumulation of CO2 in the atmosphere. Therefore, combusting biodiesel does not contribute to global climate change.

Carbon dioxide from the petroleum fuels used for fertilizer, farm equipment, or transportation during biodiesel production accumulates in the atmosphere year after year. As a result, biodiesel produces 78% less CO2 than diesel fuel overall. Biodiesel emits 2661 grams of CO2 per gallon compared to 12,360 grams per gallon for petroleum diesel fuel.

7.4.1 How does biodiesel compare with new Ultra-Low (15 ppm) Sulfur Diesel (ULSD)?

Ultra-low sulfur diesel (ULSD) has been processed to remove most of the sulfur from the fuel in order to reduce emissions of sulfur dioxide, a regulated pollutant. However, the sulfur served as the lubricant in the diesel. Therefore engines using only ULSD diesel will be subject to much higher wear factors. Fortunately, a biodiesel blend as low as 3% can replace the lubrication removed from the ULSD. It is better, though, to use at least a B20 blend which provides the engine with 20% to 50% better engine lubrication and protection than pure ULSD. This is especially important for newer diesels that have high-pressure injection pumps subject to very high wear factors.

9 Conclusions and Recommendations

9.1 Conclusions

This report has reviewed the electricity situation on the Jicarilla Apache Reservation and the energy efficiency and renewable energy options for meeting the Nation's energy needs in the future. As a result of this review a number of conclusions can be drawn from the available data.

More data is needed in several areas, but there is more than sufficient information to begin undertaking meaningful initiatives that could dramatically change the nature and quality of electrical energy use on the Reservation. This section draws out the major conclusions of the report, provides a suggested approach for synthesizing and prioritizing these results, and closes with detailed recommendations in the energy efficiency category, and with more general recommendations in the renewable energy category.

9.1.1 Conclusions regarding electricity use on the Reservation

- The Jemez Mountains and Northern Rio Arriba County Electric Cooperatives have reasonably and reliably served the Nation for many years. The Cooperatives have not, however, been strong proponents or providers of energy efficiency or renewable energy technologies and services, focusing instead on trying to maintain low rates and reliable basic service.
- Tribal electricity use grows and is expected to grow with population growth, and with the increase in use of electricity consuming appliances.
- Overall Tribal electricity use is at a manageable 3-5 MW, and is characterized by a winter peak in use.
- Due to the Nation's position on the electric grid, service in the Dulce area has been characterized by some challenges, which are expected to increase. NORA is planning transmission system enhancements in and near the Reservation.

9.1.2 Conclusions regarding energy efficiency on the Reservation

- Electricity use on the Reservation is inefficient relative to the options available for conserving electricity through changes in use and changes in efficiency of use.
- Efficiency of electricity use is directly related to the efficiency of buildings, building systems, and appliances located inside buildings.
- Aggressive Reservation-wide initiatives to improve energy efficiency could yield significant individual and tribal fiscal benefits.

9.1.3 Conclusions regarding renewable energy on the Reservation

- The Jicarilla Apache Nation enjoys high quality solar resources capable of supporting both solar electric and solar hot water technology applications.
- The Nation does not have a good wind resource capable of supporting commercial scale wind farm construction and operation. There is a potential for use of small wind machines, especially for remote, non-grid applications on the Reservation.
- The Nation may have commercially provable geothermal resources, but characterizing those resources requires further technical study.
- The Nation has considerable biomass resources that could support a pelletizing plant to support wood-fueled pellet stoves.
- The Nation could make use of biodiesel as a fuel in stationary generators that currently use petroleum diesel, but due to the lack of biodiesel refinery capabilities on or near the reservation, this is not an attractive option.
- The Nation has some micro-hydro resources that could be developed.

9.2 Synthesis and Prioritization

With such a wide variety of options and opportunities before it, the challenge that the Jicarilla Apache Nation faces is how to prioritize any efforts it undertakes in maximizing the efficiency and renewable energy resources available. Not all options are created equal; attractiveness varies according to a number of factors. Synthesis of the report findings into a useful plan requires matching the resource information against evaluation criteria that reflect values of the Jicarilla Apache Nation and Utility Authority. These evaluation criteria can be used to determine whether a particular energy efficiency or renewable energy resource available to the Nation should be developed. These criteria include:

- Resource Quality – The abundance and character of the particular resource, with a view toward how easily its value can be captured for the benefit of the Jicarilla Apache Nation.
- Cost per Unit of Energy Benefit – The simple economic evaluation of investment ad operating costs necessary to capturing the energy benefits of the particular resource.
- Local Labor Capacity to Develop the Resource – The ability of local tribal members to immediately engage in activities relating to development of the resource, including construction, operation, and other activities, or the extent to which training and technical qualification of employees is required.
- Individual Economic Benefits – The extent to which development or capture of the resource yields economic benefits directly to residents and utility customers.
- Tribal Economic Benefits – The extent to which development or capture of the resource yields economic benefits to Tribal government operations or to the people of the Jicarilla Apache Nation in the general sense.
- Durability and Reliability – The extent to which resource benefits, once captured through the installation of equipment or development of facilities, provides reliable and available energy services.
- Potential for Expansion into a Business for the Region – The extent to which investments in capturing the value of the resource can in turn be used to seed the growth of new

businesses of value, to surrounding communities and the local region.

When the resource options are evaluated against these factors, a prioritization for the Strategic Plan begins to emerge. Table 9.1 sets out a matrix of these factors against the various resource options discussed in this plan.

The analysis embodied in this report and summarized in Table 9.1 points to some fairly obvious priorities. The first and best course of action for the Jicarilla Apache Nation is to embark on a serious effort to improve efficiency of electricity use (and energy use, generally) on the Reservation. Not only do energy efficiency options offer potential for individual and tribal economic benefits with high payback on investments, activities undertaken by the Tribe could easily form the basis of a business serving the entire region.

Among the renewable energy options, small solar electric, solar hot water, and biomass pellets for heat stand out as options ripe for further study and development. While the solar electric photovoltaic and solar hot water systems are relatively expensive today, the relatively small scale of their use allows the Nation to proceed at a pace that is affordable. Moreover, solar hot water competes directly with natural gas—a resource with rising and volatile cost trends.

The biomass pellet option is an excellent one if the Tribe moves ahead with a pelletizer plant, as has been discussed of late. This decision, in turn, is economically tied to a decision about Tribal investment in a lumber mill—a decision that is currently pending.

Renewable energy options should be studied in greater detail, but should follow implementation of energy efficiency measures. The relatively high cost of renewables means that scarce investment dollars should not be "wasted" on powering inefficient loads.

9.3 Stakeholder Review and Feedback

The next steps in the strategic planning process involve validating the resources and options analysis contained in the plan with a view to ensuring that they align with the needs and interests of the Nation. This process should involve three steps:

1. The Utility Authority should present the results of the resource analysis at a workshop meeting involving key

stakeholders. These stakeholders should include Utility Authority board members and senior staff, Tribal Council representatives, Tribal government agency and department representatives, electric cooperative representatives, and others.

2. The Utility Authority should validate the evaluation criteria offered in this section against stakeholder values and preferences. Although there is some risk of “apples and oranges” comparisons, the Utility Authority can also explore some weighting among the criteria.
3. The Utility Authority should validate the priority activities identified in this Plan against stakeholder feedback. These priority items will become the Action Steps in the Jicarilla Apache Energy Plan.

9.4 Developing Action Steps

Once priority action steps have been identified through this strategic planning process, the Utility Authority can begin to develop detailed execution or “business” plans for each. Because of the importance and priority of efficient use of energy, this plan provides detailed guidance on developing this option. Details for two sub-options are included, depending on whether the Tribe seeks to emphasize energy efficiency retrofits or building weatherization.

The systematic search to eradicate energy inefficiency on the Jicarilla Apache Reservation is ideally suited to the establishment of a business or programmatic initiative. A plan for establishing such a venture is also set forth below.

Table 9.1 – Matrix Matching Resource Options against Value Criteria

	Resource Quality	Cost per Unit of Energy Benefit	Local Labor Capacity to Develop the Resource	Individual Economic Benefits	Tribal Economic Benefits	Durability and Reliability	Potential for Expansion into a Business for the Region
Energy Efficiency (Residential)	High	Low	Good	High	High	High	Moderate
Energy Efficiency (Commercial)	High	Low	Good	N/A	High	High	High
Solar Electric (Large)	High	High	Low	Low	Low	Moderate	Low
Solar Electric (Small)	High	High	Good	High	High	High	Moderate
Solar Hot Water	High	Mod-High	Good	High	High	High	High
Wind (Large)	Low	Moderate	Low	Low	Low	High	Low
Wind (Small)	Moderate	Moderate	Moderate	Moderate	Moderate	High	Low
Geothermal (Large)	Unknown	Unknown	Low	Low	Unknown	High	Low
Geothermal (Small)	Fair	Moderate	Moderate	Moderate	Moderate	High	Moderate
Biomass Pellets	High	Low	High	High	High	High	High
Biodiesel	Poor	Moderate	N/A	Low	Low	Moderate	Low
Micro-Hydropower	Good	Low	Moderate	Low	Low	High	Low-Moderate

9.5 Energy Efficiency Recommendations

9.5.1 Begin by conducting broad-based surveys

Conduct performance assessment of existing building stock by collecting baseline data of a representative sample, identifying problem areas in the building(s) if any, and assisting in pinpointing the possible causes.

The flowchart describes the steps involved in conducting the performance (thermal, visual, indoor air quality, acoustic)[1] survey of existing buildings. The baseline data gives an idea about the performance of the building as a whole and points to specific areas in the building that might need detailed analysis.

[1] Performance of interior spaces (space layout, furniture type, and furniture layout, etc.) and building energy use has not been addressed here.

Figure 9.1 - Conducting a Survey

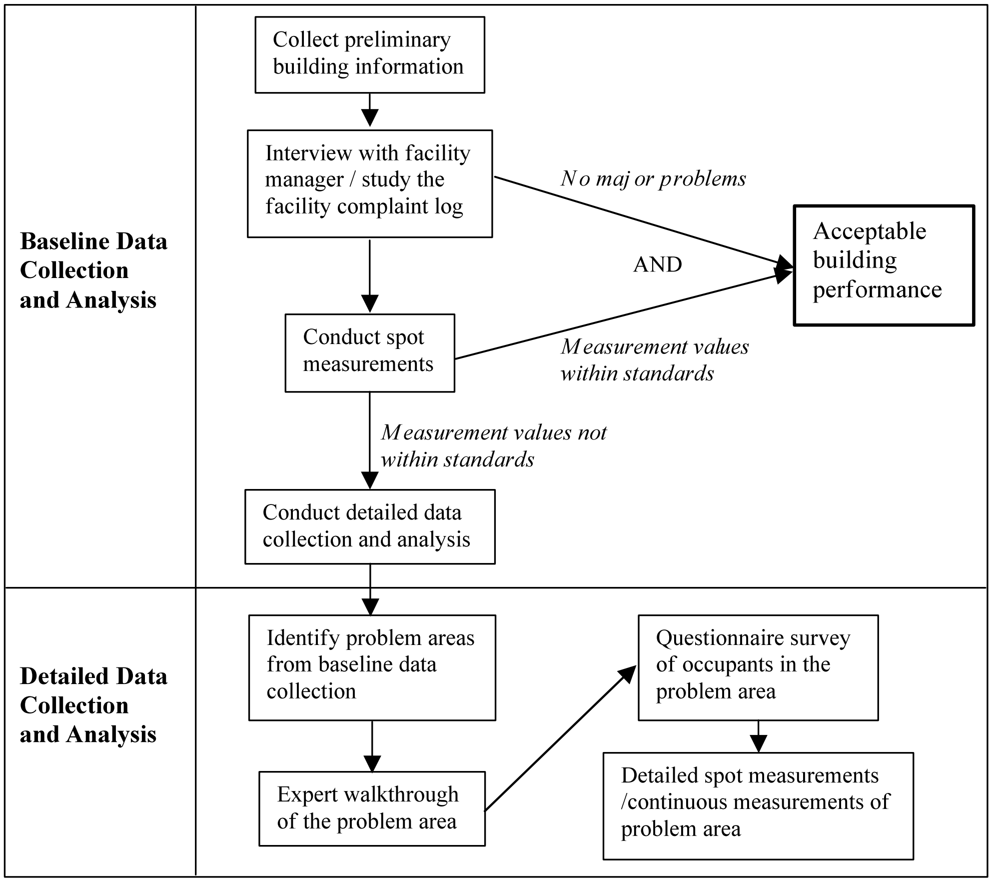


Table 9.2 gives a general idea of the indicators that would be measured during the spot measurement step (during both the baseline as well as the detailed data collection step).

Table 9.2 - Performance Indicators Measured During Baseline and Detailed Spot Measurements

Function	Baseline Performance Indicators	Standards	Detailed Performance Indicators[2] (measured if baseline performance data indicates problems)
Thermal comfort	Temperature, relative humidity	The baseline performance measurements can be compared to established standards ASHRAE IESNA	Mean radiant temperature, air velocity, supply air temperature, etc.
Visual comfort	Illuminance level		Glare index
Acoustic quality	Sound pressure level		
Indoor air quality	CO_2 level		VOC, particulates, etc.

Though a performance survey as outlined above is limited to identifying problems, the output is useful for remedial actions. For example, a performance survey might show alternating periods of very hot and very cold air being supplied. A detailed investigation can identify the problem by showing that the temperature sensor is located too close to the supply air-stream. In this case, the solution would involve moving the sensor away from the supply air stream.

9.5.2 Energy Efficiency Measures

9.5.2.1 The first step—insulation

The importance of the role of insulation in housing for the residents of the Jicarilla Apache Nation cannot be overstated. It is a

[2] Based on the baseline data, occupant survey, and the expert walkthrough, the indicators to be measured are finalized. Here, a list of possible indicators is given as an example.

primary indicator of quality of life. Because the Nation lies within the cold hygrothermal (humidity and heat) zone, there is a clear recognition by the Department of Energy (DOE) for the unique types of housing required to adequately support human habitation. (Figure 9.2) The unique climate forces the performance characteristics for materials that are utilized here to be extraordinary. This is necessary to provide a quality of life that is not adversely affected due to systemic failure or component breakdowns.

Based upon two intense days of onsite inspection, it is our opinion that the single most important work that should be undertaken is to survey the quality and the quantity of insulation in the occupied structures, assess the extent of the challenge, and secure funding to immediately address the deplorable condition of insulation in many of the residences, the lack of insulation at all, and the many instances of grossly insufficient quantities of insulation.

The Department of Energy (DOE) and the Environmental Protection Agency (EPA) recommend that in this climate, the attic insulation should be R-38 to R-49 and the wall insulation should be R-11 to R-28. It was our experience that ceiling and wall insulation was rarely ever greater than R-11.

Figure 9.2 - Department of Energy's Hygrothermal Zones

A survey, as described above, would insure that the scope of work yields the type of results that provide the best value for the Utility Authority and the tribe. A representative sample of each housing type and age group should be included in the survey. The survey should be conducted by an independent party, that is, not someone who could or would be likely to actually perform the work.

9.5.2.2 The second step—lighting

Lighting accounts for about 20% of the electrical usage of a residence, and as much as 30% of a commercial building. During the survey, data should be collected on the state of the lighting in the structures. Based solely on limited observations onsite, it appears that there is a huge lighting retrofit opportunity in both the residential and commercial sector.

Compact fluorescent lighting is three to five times more efficient than incandescent lighting. This represents the greatest savings potential for the private residence. Replacing 25% of the lights in high use areas with the compact fluorescents can reduce up to 50% of the lighting costs for a residence. In the commercial realm, our onsite investigations uncovered the fact that the predominant fixtures and lamps in the buildings are at least two generations old and some may be even older. In our opinion, retrofitting and or replacing those fixtures will result in a reduction of 15-30 % of electricity usage.

9.5.2.3 The third step—glazing

Approximately 30% of the unwanted heat and cold that enters a home does so through windows. The age and number of the housing inventory leads us to believe that a survey will document a very high incidence of single pane non-energy efficient windows in all but the very newest residential and commercial buildings. Therefore, there will be another large opportunity for energy efficiency through the selective replacement of windows.

9.5.2.4 The fourth step—trees

Strategically planting deciduous trees and providing shading for windows can help to block and refract solar radiation. The effect is to reduce cooling costs by an average of 10% with up to a possible 20%. This strategy is best for residences.

9.5.2.5 The fifth step—motors

Electric motors are responsible for 78% of the average commercial and industrial electric bill. The Department of Energy (DOE) studies show that a typical building can increase motor efficiency by 6% and save 4.5% of electrical costs. Many energy saving changes can be made with simple engineering paybacks of two years or less. There are opportunities in Dulce to implement this strategy.

9.5.3 Create a single point of contact

To effectuate the survey and to move forward, the Utility Authority must develop a plan that has the opportunity to succeed; it is recommended that the position of Energy Manager be created. The job description must include the requirement to execute the tasks necessary to conduct the survey, formulate a plan, communicate the plan, and educate the Jicarilla Apache Nation tribal members in the principles, concepts and values of energy efficiency plans and programs. These will remain requirements for this position for the duration of the program.

The Energy Manager position is long term because the education component is a long-term commitment. The duration is required because the length of time necessary to perform the work on the homes enrolled in the programs will be greater than the human capacity available for the work. Like the repainting of a large bridge, once the end is reached, the process will restart at the other end; in other words, the cycle will never end. Nationally, energy efficiency programs frequently experience the need for a repeated work scope due to the time interval to execute the work, and the size of the problem within the most needy communities. It is from this education that some future level of self-performance will occur and residents will be spared the loss of precious income in the intervening years. Energy efficiency programs can also serve as a recruiting ground for tribal members interested in doing this work, and could be the foundation for the creation of a stand-alone enterprise. Creating a business capacity to perform energy-efficiency analysis and retrofit could be the start of a regionally significant new business.

The second major component of the job description is to execute the plan through whatever means and funding are available to the Utility Authority, for the maximum benefit of those businesses, homes and owners qualifying under the program.

9.5.4 Consider two approaches to energy efficiency

There are two primary approaches to reducing energy consumption in the built environment. The first is known as weatherization and the second is known as energy efficiency retrofits. Weatherization can best be described as a series of acts that collectively will provide a reduction in the baseline energy consumption of about 10% to 15% of the energy use of building units. Weatherization is a program of small steps working around the major issues of a building. Weatherization seeks to provide quick payback for the capital invested for the scope of work executed. In the vernacular, it is the picking of the "low-hanging fruit."

The scope of weatherization projects has been determined largely by the requirements of the Federal government and the Federal assistance programs frequently mirrored by State utility regulators and utility companies. There is no absolute reason to follow these guidelines on the Jicarilla Apache Nation if the utility authority is going to fund the work. If, however, there is external funding sought (possibly, from the Federal government), the established definition and pattern for weatherization will prevail.

There is one liability in following the Federal guidelines. Sometimes a home may have more repair issues than can be satisfied by the program's standard definition. This problem typically occurs in about 6% of homes. The consequence is that until the house is repaired to a level sufficient to meet the minimums of the program, the residence remains at status quo, denying the occupants potential utility bill reductions and a healthier home environment. The effect penalizes the worst of the poorest performing houses. Thus, any weatherization program conducted by the Utility Authority should account for this possibility and adapt the program or secure support to address these hardship cases as a first step of the program, rather than omitting them and setting the houses aside.

9.5.4.1 Weatherization

The first step in a weatherization program is conducting an energy performance audit.

Examples of activities that would be included in a typical residential program include:

- A financial means test to qualify participants
- An energy performance audit of the structures; composed of a blower door test, an infrared scan of the building envelope, and a combustion safety test of the heating system
- An analysis of the test data to determine the most likely candidates
- Mobilization of a contractor or a work crew
- Finalization of the work plan and assembly of the materials

A typical weatherization program includes the following activities:

- Air sealing (caulking, foam sealing, gaskets for outlets)
- Duct testing and whole-house testing
- Attic insulation
- Door weather stripping
- Storm door addition
- Replacement of door(s)
- Solar screen application
- Repair duct leakage
- Filter installation
- Replacement of incandescent lamps with fluorescents

- Programmable thermostat installation
- Hot water blanket installation on hot water heaters

9.5.4.2 Energy efficiency retrofits

The retrofit program picks up where the weatherization program stops. It deals with more substantive issues in a residence and it generally yields greater cost savings in return. Examples of retrofit projects that would be included in a typical residential program are as follows:

- An energy performance audit consisting of a blower door test, an infrared scan of the building envelope, and a combustion safety test of the heating system
- Radiant barrier application
- Window replacement
- Roof replacement
- Appliance upgrade to EnergyStar rated appliances
- Duct replacement
- Furnace repair or replacement
- Air conditioning unit repair or replacement
- Envelope replacement
- Wall insulation replacement
- Hot water heater replacement
- Planting of deciduous trees on south and/or west side of lot
- Onsite grinding of the construction and demolition waste generated by the retrofit

A commercial energy efficiency retrofit program would entail all of the above steps. But, the hierarchy of the simple engineering paybacks that would be used to determine which systems to retrofit would begin with lighting, insulating, pumping, powering, and then subsequently, the building envelope issues, such as the roof membrane, fenestration, and tree shading.

9.5.4.3 Weatherization

Eligibility Process

An important first step in establishing a weatherization program is the creation of eligibility criteria. These criteria can be used to allocate level of effort and resources, to prioritize caseload, and to better support budgeting and planning.

Proposed Weatherization Program Eligibility

To participate in the Jicarilla Apache Weatherization Program, one must bring the following information:

I. Verification of income for all working persons over the age of 18 living in the home. Each working person must bring the following documents to be eligible for the weatherization program.

If working, check stubs from employer (at least two months)

Social Security Award Letter

Pension benefit documents

IRS tax return from the previous two years

Bank statements for the previous three months

Copies of annuities

Tribal allotments

II. Copy of Recorded transfer of Trust.

III. Copy of Birth Certificate.

IV. If divorced, a recorded copy of Divorce Decree indicating home ownership.

V. If delinquent taxes exist, a copy of the letter of approval for a tax deferral from the tribe.

VI. A copy of current New Mexico Drivers License or State of New Mexico photo Identification Card.

Residents must be willing to sign the following documents that will be provided by the Jicarilla Apache Nation Utility Authority:

- A participation statement confirming that the resident has not received any previous assistance from the JANUA.
- A copy of a waiver and release for informal bidding.
- An affidavit release form.
- A notarized statement from a third party for liability release.

Presuming that this or some facsimile of qualification it employed, the administrative responsibilities will have to be executed by some staff members. During the decision-making process, some applications will be denied—a practical and political reality of the program. Because approval is likely a JANUTA board decision, the Energy Manager should not be involved in the process.”

Practical considerations

There are practical considerations for the technologies of the weatherization and retrofit plans. We believe that they are manageable considering the skill level of JANUA management. The complication, if there is any, may come from the analytical first steps of the program. That first step is conducting the blower door and duct leak testing, infrared scanning, and combustion safety testing of the heating system.

Certified personnel must conduct the analytical tests. Currently there are only two New Mexico firms certified by the Residential Energy Services Network (RESNET) to conduct the tests. Such tests are very important; they are the foundation of the entire program. The tests help determine the potential for each individual structure and the weatherization program in total. Additionally, in many instances, they will inform the decision on what to retrofit and at what level.

Certified raters

A business opportunity arises from the process of testing 1,000 structures on the Reservation. The question is whether the Utility Authority should perform the testing. If so, the Authority should undertake the recruiting and training of individuals to become certified raters.

If the Utility Authority concludes that this is the case, then another series of potential opportunities may exist such as seeking out weatherization business from other tribes or communities in New Mexico. The critical success element becomes the training of personnel to become certified to conduct the blower door, duct and combustion testing and the infrared scanning**.**

There is every reason to believe that the Utility Authority possesses the ability to attract and maintain the quality of skilled workmen necessary to effectuate the testing program. The Authority is capable of doing this based upon observations of and conversations with current staff. In order to ensure long-term occupation for skilled workmen, the enterprise model targeting the broader region should be explored.

Weatherization implementation personnel

The Utility Authority has the ability to attract, train, motivate and maintain quality workmen. The skills necessary to effectuate the weatherization program elements are not deemed to be complex. In fact, the skill-sets required to make the weatherization program run well are suited nicely in a progression to the energy efficiency retrofits and to the more detailed maintenance jobs within the Utility Authority.

Possible opportunity for synergy

Jicarilla Construction has personnel entirely capable of working in or making a material contribution to this effort. This could be a promising opportunity to partner with other tribal government agencies. The labor-intensive nature of weatherization provides the opportunity to acquire and train skilled workmen, and retain trained personnel.

Supply chain

The supply chain issues will be determined by the speed or timing in which the authority chooses to execute the program. With sufficient financial resources available, an adequate inventory can be obtained and maintained to address the population base. It is a matter of programmatic management and an understanding of policy leadership. We continue to assume that the Authority has safe, secure storage facilities for the materials.

None of the materials are exotic. None are unduly heavy or bulky, and with the possible exception of the solid core exterior doors, none are expensive. One minor technical matter is insulation. Although blown-in insulation offers ease of installation and better performance, reliance on traditional insulation batts could save on capital investment and training while increasing demand for labor. Compact fluorescents are now widely available. Lastly, the required tools are common to every workman’s tool chest. A reasonably planned and executed weatherization program should have no difficulty operating in Dulce.

Transportation

Although it may be relatively difficult to get to Dulce in the middle of the winter, modern transportation systems utilized by industry to deliver goods to customers have progressed significantly. The material required in the weatherization program is neither exotic nor bulky. In fact, some manufactures (insulation in particular) might compete heavily for this work because it would represent an economically attractive large order. All materials are readily available at big box stores in both Santa Fe and Albuquerque. The schedule of the work should not come into conflict with the onset of winter if the plan is facilitated correctly.

Evaluation

The Utility Authority will need to decide which energy efficiency improvements are important, and whether a weatherization program can address those needs, or whether a program of energy efficiency retrofits is appropriate. It may be the case that both approaches (weatherization and energy efficiency retrofits) are required. The Authority will have to consider this important issue when developing the program.

To begin framing the context for decision-making, the Authority will need to ask the following:

- Should the desired results of any program be isolated to either residential customers or commercial/ institutional?
- Are residential improvements in the 10 to 15% range leading to real dollar savings, better occupant comfort, increased safety, productivity, and cultural compatibilities?
- Can JANUA make the personnel investment to self-perform the weatherization program?
- Is there capital or operating maintenance improvements needed in tribal buildings that will be completed by the tribe without any assistance by JANUA's plan?
- Are there "upgrades" that will help the tribe better meet its mission or its political priorities?
- Are the commercial/institutional energy dollar savings going to yield real dollar savings?
- Will there be better occupant comfort, increased safety, productivity, and cultural compatibilities?

These are but a few of the critical issues to be worked through. Table 9.3 can assist in the decision-making with regard to a weatherization program. The table rank-orders the four critical factors we considered important; cost, maintenance once installed, the ease of implementing the tactic, and the potential for generating energy savings as a result of the tactic.

Table 9.3 - Weatherization Evaluation Assessment

Measure	Cost	Maintenance	Ease of Implementation	Energy saving potential
Air sealing	Low	Low	Moderate	High
Duct and whole house testing	Moderate	Low	High	High
Attic insulation	Moderate	Low	Low	High
Door weather stripping	Low	Low	Low	Moderate
Storm door addition	Low	Low	Low	Moderate
Replacement of door(s)	Moderate	Low	Moderate	Moderate
Solar screens applied	Low	Low	Low	Moderate
Repair duct leakage	Moderate	Moderate	High	Moderate
Filter installation	Low	Low	Low	Low
Replace lamps	Moderate	Low	Easy	High
Hot water blanket installation	Low	Low	Low	Moderate

9.5.4.4 Energy efficiency retrofits

The practical considerations for the technologies of the energy efficient retrofits plan are more complex than the weatherization plan requirements, but they should be equally manageable if taken in logical progression and not rushed to some arbitrary end. The complexity of the energy efficiency plan resides in the capital requirements required to effectuate the program. This could become a substantial financial investment.

Energy efficiency retrofits personnel

The Utility Authority has the ability to attract, train, motivate and maintain quality workmen. The Authority can develop the skills necessary to effectuate a significant portion of the energy efficiency retrofits. As with weatherization, the skill sets required for the energy efficiency retrofit program are analogous to the more detailed maintenance jobs within the Utility Authority.

There are some tactics that may be too complex. When this occurs, contractors who routinely work in these areas can be hired.

Possible opportunity for synergy remains

It is the case that some Jicarilla Construction personnel will be capable of working in this effort. This could be another opportunity to partner with the Utility Authority.

Supply chain issues

As with weatherization supply chain analysis, the rate with which the work is undertaken will largely determine the stress on the supply chain and JANUA personnel. Furthermore, capital expenditures require more time in most instances. This is well known and should be allowed for in the planning process. Moving the materials for energy retrofits will require a well-structured purchasing process and associated contracts.

Transportation

Although it may be relatively difficult access Dulce in the middle of the winter, modern transportation systems utilized by industry to deliver goods to customers have progressed significantly. The materials required in the energy efficiency retrofits program are neither exotic nor bulky. All materials are is readily available at big box stores in both Santa Fe and Albuquerque. The schedule of the work should not come into conflict with the onset of winter if the plan is facilitated correctly.

Table 9.4 can assist in the decision making with regard to an energy efficiency retrofit program. We rank-ordered four critical factors: cost, maintenance once installed, the ease of implementing the tactic, and the potential for generating energy savings as a result of the tactic.

Table 9.4 - Energy Efficiency Retrofits Assessment

Measure	Cost	Maintenance	Ease of Implementation	Savings potential
Radiant Barrier application	Moderate	Low	High	Moderate
Roof replacement	High	Moderate	High	High
Window replacement	High	Moderate	High	High
Appliance replacement	Moderate	Low	High	Moderate
Duct replacement	Moderate	Low	High	High
Furnace repair	Low	Moderate	Mod-high	Mod-high
Air conditioning unit repair	Moderate	Low	Moderate	Moderate
Air conditioning replacement	High	Low	Mod-high	Mod-high
Programmable thermostat installation	Low	Low	Low	Moderate
Wall insulation	Moderate	Low	Moderate	Moderate
Hot Water heater replace	Moderate	Low	Moderate	Moderate
Envelope replacement	High	Moderate	High	Mod-high
Planting trees & landscape	Moderate	Moderate	Moderate	Low

9.5.5 Education and outreach

The key to a successful energy efficiency management program is to allow the energy manager to actively engage in education and outreach functions necessary to assist citizen and building management’s understanding of the benefits and costs of the program. Essential to this step is an analysis of the precise decision-making process used to apply a given technology in the program. The communication of the plans to the public should be a well-orchestrated, educational effort supported by the Utility Authority and the Tribe. The education and outreach program will need to be in place for a number of years, post-implementation. This allows for the program to be executed, the system maintenance-training to develop, and the periodic renewal process for homeowners to take place.

The Utility manager should play a leading role in the formulation of the educational program and he/she should actively promote this training in multiple venues. It is strongly suggested that this program involve a multi-level approach that includes non-homeowners/business owners as well as school children. There is an urgent need to develop a consciousness for energy efficiency and utilization.

It is the case that almost all energy efficiency programs have financial and societal requirements associated with the program. Presumably, this would be the case for the Utility Authority to move forward. Thus, one of the most important concepts to be shared in the plan with the community is the detailed explanation of those requirements. In the following paragraph we provide a proposed set of guidelines for consideration.

9.5.6 Business development plan

We recognize that the consequences to JANUA administrative and technical staff will be significant. We also recognize that the business requirements for support of the plan are important. Therefore, we offer the following recommendations relative to establishing a functioning plan that has the likelihood of successful implementation.

- Analyze internal resources to determine capability of self-execution of weatherization and energy efficiency retrofits separately.
- Determine what external options are available, are affordable, and are acceptable.
- Decide what the correct balance of internal and external resources is required to plan and implement the project(s).
- Determine and get approval for a pilot project, budget, and team.
- Execute the pilot project; collect data, document the process, evaluate lessons learned communicate the results.
- Seek authorization for a revised (improved) project based upon pilot results.
- Decide who must be included in regular communications as the project develops, and how communications will occur.

- Decide what financial expectations are expected of the project(s).

9.5.6.1 A mini master planning exercise

A number of contracted capital improvements are always underway in Dulce. Following the completion of some of that improvement work, the tribe and JANUA should consider doing some small scale master planning for Dulce proper. The authors suggest the exploration of the walking pedestrian city center concept. This concept could include the casino, the restaurant, lodging, and a conference facility and might also include a Culture Center.

The primary idea behind a Culture Center concept could encompass all of the existing icons and symbols of the tribe as well as an interpretive center to tell the proud story of the Jicarilla Apaches. It might also include a small museum to display the many treasures of the culture. Due to the nature of the place and the role that hunting and fishing play in the community, it might also make sense to explore the inclusion of a facility to display the magnificent big game trophies which are currently housed at the Game and Fish location. The idea is that if the hunters were located and housed in a location that has food, entertainment and their licensing agency, they might spend more money, bring family members, and promote the site more as a destination.

The mini master plan could also consider adaptive reuse options consistent with a plan for the old jail building and for the administrative offices of the tribe. We believe that by creating a comprehensive plan for the district, the Culture Center could bring great honor and respect to the Jicarilla Apache Nation’s peoples.

9.5.6.2 Greenfield development; new residential construction

A growing number of communities are interested in “green building” products and practices for new residential development, design and construction. Many programs are designed as a voluntary, builder and market-driven solutions. Still others are more effective at driving markets by employing mandatory regulations. Due to the unique nature of the Jicarilla Apache Nation land use and home construction, it is not practical to consider a market based voluntary approach to developing guidelines for greenfield development.

The Authority should develop a clear understanding of its objectives. Does JANUA want to:

- Promote building practices that represent resource-efficient construction?
- Promote building practices that represent energy efficient construction?
- Stimulate market demand for cost-effective, environmentally-friendly construction?
- Provide education builders, remodelers, home buyers, home-owners and tribal officials the benefits of green building practices?
- Encourage the use of new technologies and building practices?
- Expand its developmental activities in the area with a set of regulations that it controls?

Presuming that the answer to most of these questions is affirmative, the JANUA board will have to consider and make a number of decisions. Some of those that will need to be addressed include:

- What is the benefit of a green building or new construction program?
- How do you implement and manage a program?
- Who would educate the buyers?
- How do you verify and certify a house’s performance?
- What is the cost of such a program?
- What is the budget for implementation and administration?
- Who would train the builders?
- How do the verifiers or certifiers receive training?
- How would you market the program to the tribal members?
- Would you charge a fee (per house/builder/range of homes)?
- Could you obtain sponsors or other sources of funding to help pay for the program?
- Who would educate the realtors in the surrounding community (business enterprise approach)?

9.5.6.3 Program development

The Board's key task is to articulate the principles and values that it desires to govern the mandatory program. It is highly likely that a consultant will be hired to develop the program that includes the principles, values, format, framework, final features and checklists, a step by step process for implementation, and options for technical support.

The Board will need to provide a plan for training staff, builders, contractors and verifiers. In addition, the Board will need to assist JANUA management in setting up the administration of the program including the verification and certification methods, tracking and maintenance.

JANUA management will need to establish the budget for the program, and secure Board approval. Management will need to develop funding sources such as sponsors or government grants for some financial assistance in the start up phase. The Board and management will need to engage in significant long term planning to develop this aspect of the energy efficiency measures the Board is considering.

The following sets out the core elements of a greenfield development program:

9.5.6.4 Core elements of new home design

First and foremost, build only EPA EnergyStar qualifying homes!

Site development

- Site is not located on environmentally sensitive area.
- Locate new projects on sites with access to existing roads, water, sewers and other infrastructure within, or contiguous to, existing development, or provide easement and utility trenching plan consolidating trenching where allowed by code
- Use reasonable efforts to protect all trees during construction including the use of tree fencing, limiting the amount of fill dirt on the root system and limiting any trenching around the trees.
- Minimize site disruption by designating parking, equipment and material storage and staging away from root protection zones.
- Provide surface drainage away from foundation.

- Achieve a 50% waste diversion from the landfill standard by sorting, recycling and disposing of construction waste.
- Conform to local or state regulations or implement EPA Best Management Practices for erosion and sedimentation control during construction.

Energy

- Make sure home exceeds latest version of International Energy Conservation Code (2003 IECC) by 15% or obtain Home Energy Rating of 86 (both are required to qualify home as Energy Star®; third party documentation required must have documentation and notarized).
- The effective R- value of the building envelope is met by the use of continuous insulation, advanced framing techniques and/or a structural insulation system such as Structurally Insulated Panels (SIPS), solid or infill wall system, Insulated Concrete Forms (ICF), ACC or advanced framing with insulated corners, straw, or rammed earth.
- Provide power venting or sealed combustion providing fresh combustion air for gas furnaces and water heaters located inside conditioned space.
- Vent kitchen range hoods to the exterior (for single family detached homes).
- The Dishwasher is an EPA Energy Star labeled product.

Materials

- Optimum framing standards are used.
- Urea-formaldehyde free materials only are used.
- Recycled or reclaimed content materials are used for the foundation.
- Recycled or reclaimed content materials are used for framing.
- Recycled or reclaimed content materials are used for flooring.
- Recycled or reclaimed content materials are used for the exterior envelope of the home.
- Provide a minimum twenty-five year manufacturer’s performance warranty for roof (recommend EPA Energy Star roofing requirements).

- Outdoor structures, decking and landscaping materials made with 50% or greater recycled content.

Health

- Use 1” pleated paper filters for central air conditioners or install whole house Media filter
- If garage has common wall(s) with house, make walls airtight; or have detached garage.
- For homes with gas appliances or attached garage, install one carbon monoxide detector with American Gas Association (AGA) IAS696 Blue Star Certification Seal every 1,000 sq.ft. (near bedrooms) at a minimum of one per floor.
- Any fireplace installed must have combustion air direct from exterior; or no fireplace installed.
- Seal ducts during construction before first use.
- Interior paint must not exceed VOC content of 50 grams/liter; varnishes, enamel finishes and adhesives not to exceed 150 grams/liter of VOC’s.
- Do not use vapor-retarding materials on interior surfaces.

Water

- Utilize water efficient sink fixtures (1.8 gpm for bath; 2.0 gpm or less for kitchen).
- Locate water heaters or storage tanks within 20 feet of fixtures or install hot-water-on-demand systems, or tankless water heaters, or manifold plumbing systems utilizing PEX tubing.
- Add only native landscaping.
- Mulch vegetation.