VIEJAS
TRIBAL GOVERNMENT

Renewable Energy Development on Tribal Lands of Viejas

FINAL DRAFT REPORT
B&V Project Number 135650

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Black & Veatch Corporation
11401 Lamar
Overland Park, Kansas 66211
Tel: (913) 458-2000 www.bv.com

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Principal Investigators:
Mike Elenbaas, Project Manager
Terrance Meyer, Project Engineer
Ryan Jacobson
Ryan Pletka
Gary Wilmes

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1.0 Executive Summary

The purpose of this study is to investigate the feasibility of Renewable Energy Development on the lands of the Viejas Band of the Kumeyaay Indian Nation. In addition, the study will investigate the feasibility of forming a renewable energy based tribal utility. Viejas contracted with Black & Veatch and Fredericks, Pelcyger & Hester, LLC to assist in the development of a feasibility study to ascertain the economics and operational factors of forming an electric and water utility. This report is the result of the investigation conducted by Black & Veatch, with input from Viejas Tribal Government. Fredericks, Pelcyger & Hester, LLC performed Legal Analysis for the investigation. The results of the Legal Analysis are included as Appendix D to this report.

1.1 Strategic Options

Net metering is an arrangement with SDG&E where renewable generation sources on Viejas property feed through the existing electrical meters. Each meter is only billed for the net energy consumed over a one year period. California's net metering law allows up to 1MW of renewable generation per meter to be placed on a net metering rate. Any generation in excess of consumption is forfeit. One approach to integrating renewable energy into the Viejas energy mix would be to leave the existing structure and relationship with SDG&E in place and simply net meter renewable generation on the reservation.

Use of net metering would not exclude formation of a utility at a later date. Generation assets could be built up under net metering agreements with SDG&E until such time as utility formation would be implemented. Net metering would allow Viejas to gain operational experience through management of net metering projects prior to formation of an electric utility. The Self Generation Incentive Program (SGIP) in California gives the Net Metering arrangement a significant economic advantage as compared to other renewable alternatives.

Another approach to self generation would be formation of a separate utility. The tribal utility would have a wheeling agreement with SDG&E and power purchase agreements with energy suppliers. The tribal utility would likely operate most of the on-reservation generation. By interacting with the grid, a Viejas utility is not required to produce all of the energy needed by reservation loads moment by moment.

A disadvantage of forming an independent utility is that it is not possible to take advantage of the California incentive programs mentioned in the net metering section. Furthermore, by interacting with the grid, Viejas would still be vulnerable to grid outages and, depending on the type of power purchase agreement, vulnerable to price fluctuations.

A third approach for self generation would included establishing a tribal utility that would be capable of providing all generation needs independent of the outside grid. A connection would likely still be in place, but an outage or a cost of energy increase on the grid would not necessarily translate into either an outage or dramatically increased cost of energy on the reservation.

A larger investment with lower return would be required to meet the self sufficiency goal of this scenario as compared to the interactive utility scenario. In addition to power quality equipment reliability would require redundant generation. Furthermore the generation profile would, by necessity, be heavy on firm or dispatchable generation, such as thermal generators (fossil or renewable fueled), as opposed to the variable energy sources such as solar and wind, unless significant energy storage is added.

1.2 Energy Profile

Hourly load data for the year 2003 was acquired for Viejas' large customers from SDG&E. This data was used to generate an hourly load profile for these customers located within Viejas land. This hourly load profile is an important assumption used in the generation optimization model, and serves as the basis for dispatching generation using Black & Veatch's production cost model, POWRPRO.

For residential customers, assumptions were developed by applying hourly residential load profiles for a comparable California utility to the number of residential customers on Viejas land.

The total energy used in this report's analysis is 24,018,539 kWh for 2005. The annual escalation of energy is assumed to be 1.70%. A peak demand of 5,217 kW is assumed for 2005, with an annual escalation of 1.70%.

1.3 Renewable Alternatives

The following list of renewable generation alternatives was evaluated in this feasibility study. Detailed assumptions for each technology type including unit size, operating characteristics and cost characteristics are documented in Section 5.0.

- Wind
- Solar
- Bio-fuels
- Cogeneration

1.4 Other Issues

In addition to the renewable generation alternatives, this study also investigates the following:

- The study investigated Energy Storage Technology options and Load Management alternatives for Viejas Tribal Government. These options are discussed in detail in Section 6.0.
- Electrical Interconnection Options for connection to the transmission grid are detailed in Section 7.0.
- Distribution System assumptions are detailed in Section 8.0.
- An Environmental Assessment is detailed in Section 11.0.
- A Tribal Benefit Assessment is detailed in Section 12.0.
- A Business Plan is discussed in Section 14.0.

1.5 Legal

Fredericks, Pelcyger & Hester, LLC performed the Legal Analysis for the investigation. The results of the Legal Analysis are included as Appendix D to this report.

1.6 Generation Mix Optimization

A primary output of the Generation Mix Optimization process is a levelized cost comparison of the available renewable technologies. Figure 1-1 shows the range of likely Levelized Cost for each technology. A description of the Optimization approach is found in Section 10.0. Generation technology assumptions are detailed in Sections 5.0 and 6.0.

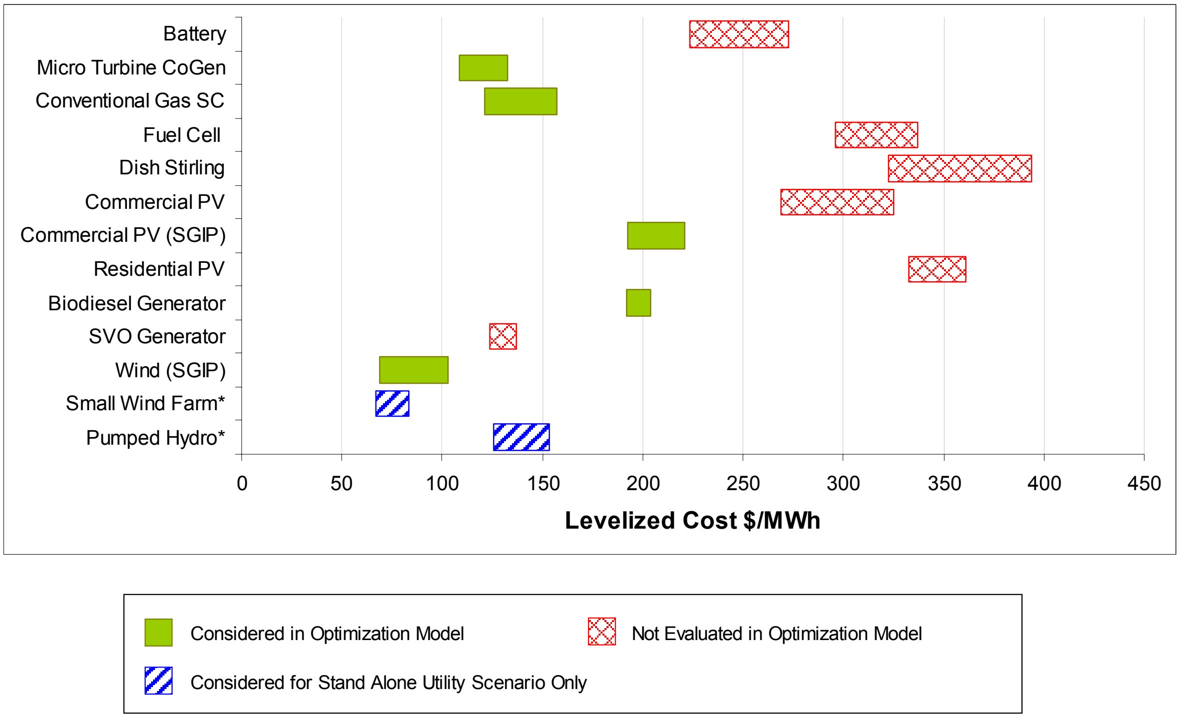

Figure 1-1. Levelized Cost Results

* The assumptions used for the Small Wind Farm and Pumped Hydro are dependent on both technologies being installed on the El Capitan Reservation.

In Figure 1-1, the levelized cost of the technologies highlighted in checkered red are uneconomic in comparison to the other options, as well as in comparison to the rates Viejas is currently paying for electricity. Therefore, these options were not evaluated further in the optimization process. Section 10.0 discusses the results in detail.

1.7 Economics

1.7.1 Net Metering Planning Scenario

The results of the Net Metering Planning Scenario analysis indicate that of the three scenarios, the option to install three 1 MW wind turbines for net metering against Viejas' largest three meters has the highest 10 year Net Present Value (NPV). Under this scenario's Base Case, the 10-year cash flow analysis yields an NPV of $651,000.

While the base case analysis for the three turbine scenario yields the largest NPV, Black & Veatch notes that the policies governing both net metering and the SGIP program do have limits to what can be done at a single site or by a single owner. How these rules apply to these three meters was not specifically analyzed. The study assumes all three turbines receive the SGIP capital cost credit. The three turbine scenario should be considered contingent on meeting the regulatory requirements governing the program.

Section 13.2 includes a sensitivity analysis of key risk factors for the Net Metering Base Case scenario.

1.7.2 Interconnected Utility Planning Scenario

The 10 year net present value cash flow analysis shows that for the base case assumptions used, the formation of an electric utility is not economically viable. The base case scenario for the economic assessment assumes no renewable generation is installed by Viejas. For the interconnected utility planning scenario, the base case yields the most attractive 10 year NPV when compared to the renewable generation alternatives. The 10 year NPV for this base case is negative $1,929,000.

Section 13.2 includes a sensitivity analysis of key risk factors for the Interconnected Utility Base Case scenario.

1.8 Conclusions

The Economic Analyses performed indicate that should Viejas become eligible for California's SGIP program, a Net Metering Wind Turbine Installation would be feasible under the base case assumptions. The sensitivity analysis indicates that wind turbine capacity factor is the largest driver of 10 year NPV for this planning scenario. Therefore Viejas should continue to monitor wind speeds via one or both of its anemometers.

The Interconnected Utility planning scenario economic analysis indicates that formation of a tribal utility would not be feasible under the base case assumptions. The top drivers for this scenario include the regulatory risk of reconfiguration costs, as well as market factors such as power supply cost. The sensitivity analysis indicates that annual average supply costs of $59/MWh (in year 2005 dollars) or less would yield a positive 10 year NPV for the interconnected utility base case.

California's Self Generation Incentive Program (SGIP) is one of the primary drivers for wind to be an economically viable renewable generation option for Viejas. It will be important for Viejas to apply now for the SGIP in order to maximize its chances of obtaining any available funds from the program.

2.0 Introduction

2.1 Objective

The objective of this study is to investigate the feasibility of Renewable Energy Development on the lands of the Viejas Band of the Kumeyaay Indian Nation. In addition, the study will investigate the feasibility of forming a renewable energy based tribal utility.

Specific objectives of the study include:

- Assessment of renewable energy resources and technology (solar, wind, biomass) specific to the reservation
- Development of a detailed reservation load profile
- Assessment of energy storage and load management opportunities
- Analysis of electrical interconnection options
- Audit of the existing distribution system
- Legal analysis of the regulatory implications of forming a tribal utility
- Optimization study to determine the most cost effective generation and load management mix
- Assessment of environmental issues
- Assessment of tribal benefits
- Economic assessment of the potential renewable energy utility
- Development of a business plan for the renewable tribal utility aligned with overall tribal goals

2.2 Background

The Viejas Tribal Government selected Black & Veatch to perform a study to investigate the feasibility of forming a renewable energy based electric utility company as Viejas continues to investigate electrical generation and energy supply alternatives. Currently, Viejas receives all of its power and natural gas from SDG&E. Market volatility in the California market has affected almost all of the State's retail customers in the recent past. Viejas is no different in that it has been subjected to price increases for its electricity. Thus, Viejas has begun to seek out alternative sources of renewable energy.

Two circuits feed the reservation distribution system, and no other distribution circuits intersect the Reservation's boundaries. Ample space exists within the boundaries to support self-generation if pursued, and sufficient space exists for normal residential growth. The primary obstacle into forming an electric utility will be the cost and arrangements to physically deliver electricity to the Viejas distribution system. The difficulty stems from the fact that the Alpine substation is approximately eight miles away and distance complicates the delivery arrangements Viejas will have to make for its electricity supply.

2.3 Approach

The project approach and tasks involved are shown in Figure 2-1 below. Generally, the study investigates which renewable technologies are optimal for the environment of the Viejas Reservation. The study is based on a projected load profile of the reservation and renewable resource availability and technology characteristics. The POWROPT generation mix optimization model determines the best mix of resources to minimize cost while ensuring high reliability of supply. Section 10.0 describes the optimization process and models used in detail. Candidate technologies include solar, wind, biogas, biodiesel, and demand side management strategies. These alternatives are discussed in detail in sections 5.0 and 6.0.

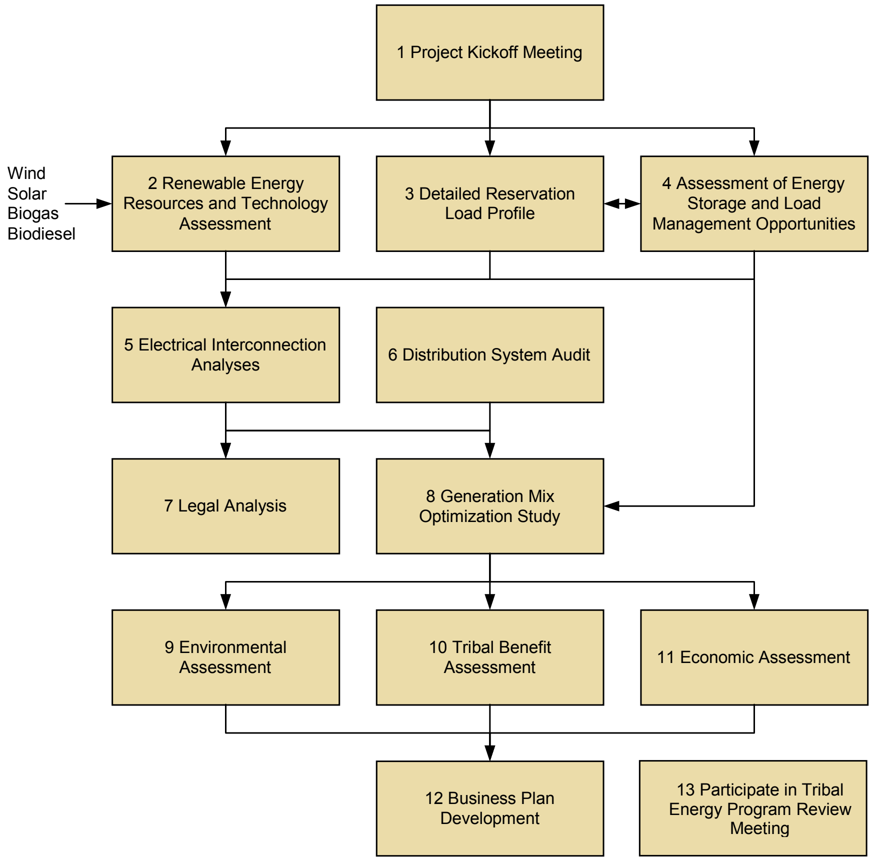

Figure 2-1. Study Flow-Chart

The study investigates three other primary areas: (1) a distribution system audit to determine the value of the existing utility electric system, (2) analyses of the various interconnection options, and (3) a legal review to verify the legitimacy of the proposed utility. Based on these investigations, the discounted cash flow analyses are performed to gauge the economic viability of the various options. In addition, environmental and tribal benefit studies are conducted, and an outline of a business plan to implement potential initiatives is presented.

Black & Veatch used a discounted cash flow methodology to evaluate the financial feasibility of forming an electric utility. This methodology was used because comparison between different scenarios is relatively easier to perform and because it provides an estimate of the expected revenue streams. A detailed analysis, including but not limited to actual installed equipment and original cost information, is required to determine the actual cost of specific report items.

This report is a feasibility analysis for Viejas that includes the best market information known at this time. The optimization study and economic analysis sections use energy supply costs that are general estimates provided to Viejas to give an indication of the magnitude of these costs. Therefore, many of the financial and engineering assumptions will need to be studied further to develop specific detailed information.

3.0 Strategic Options

Viejas has several options in gaining more energy self sufficiency and economy. The options presented below cover the range of possibility. These options may be seen as independent options or as stages, one leading to the other in a long term strategy.

3.1 Net Metering on Individual Accounts

Net metering is an arrangement with SDG&E where renewable generation sources on Viejas property feed through the existing electrical meters. Each meter is only billed for the net energy consumed over a one year period. California's net metering law allows up to 1MW of renewable generation per meter to be placed on a net metering rate. Any generation in excess of consumption is forfeit.

One approach to integrating renewable energy into the Viejas energy mix would be to leave the existing structure and relationship with SDG&E in place and simply net meter renewable generation on the reservation. Renewable generation projects could be scaled to approximately match the annual energy consumption at the meter to which they were interconnected. On a project by project basis it can be decided if a project is desirable based on economic and other factors.

The biggest advantage of a net metering scenario is that SDG&E, in affect, acts like a perfect battery, storing and releasing energy with zero losses. Thus the need for on site energy storage or supplemental generation on site to supply all loads at all times is completely avoided. Another advantage is that at Viejas both solar and wind resources are greatest in the afternoons when power is most valuable. Thus by picking a favorable time-of-day rate, Viejas would be able to gain more than one-to-one credit for excess energy produced in the afternoon and consumed at night. Furthermore, California has two strong incentives for projects under 1 MW capacity, the California Energy Commission buy down program for projects under 30 kW and the California Public Utility Commission Self Generation Incentive Program (SGIP). Viejas may be able to be take advantage of these incentives for greater than 1 MW worth of projects by applying for them each separately on a different account. These incentives would not be available to an independent Viejas utility. It should be noted that the Self Generation Incentive Program (SGIP), which is for projects over 30kw, is very heavily subscribed to and there is currently a waiting list. Availability of this incentive has been assumed for these analyses but its actual availability is not certain and is subject to future funding levels and rule changes.

Generation projects which do not feed electricity back into the grid do not require a net metering agreement. Thus smaller projects, sized below the minimum load of the meter, will not have to meet net metering requirements. This type of project is included in discussions of “net metering” throughout the report since it performs the same function of reducing energy costs behind a meter.

Disadvantages of the net metering approach are mainly associated with the fragmented implementation required. Excess generation at one site does not compensate for deficient generation at another. Furthermore, net metering limits siting of projects to the site of the meter used, which may not be ideal from a resource or space perspective. Integration of diverse elements of generation, load shifting and cogeneration is constrained by the ‘walls’ between individual meters. Although net metering does provide some energy security because consumption is reduced, Viejas does not have control over the electrical system as a whole and would still be quite dependent on SDG&E.

Use of net metering would not exclude formation of a utility at a later date. Generation assets could be built up under net metering agreements with SDG&E until such time as utility formation would be implemented. Net metering would allow Viejas to gain operational experience through management of net metering projects prior to formation of an electric utility.

3.2 Tribal Utility Interactive with the Grid

A more aggressive approach (or a second stage) to self generation would be formation of a separate utility. The tribal utility would have a wheeling agreement with SDG&E and power purchase agreements with energy suppliers. The tribal utility would likely operate most of the on-reservation generation.

Forming an independent utility gives Viejas the ability to select energy suppliers (and customers for excess energy). Coordination of reservation-wide load shifting, generation, and cogeneration activities is greatly facilitated by having all loads behind one ‘door’ to the grid at large. It becomes more desirable and effective as an independent utility to integrate energy storage or dispatchable generation to avoid capacity charges and minimize on peak electricity usage. By interacting with the grid, a Viejas utility is not required to produce all of the energy needed by reservation loads moment by moment. Generation, storage, and load management projects can be selected using whatever economic or other criteria deemed necessary without the burden of being required to meet loads with on site resources.

A disadvantage of forming an independent utility is that it is not possible to take advantage of the two California incentive programs mentioned in the net metering section. Furthermore, by interacting with the grid, Viejas would still be vulnerable to grid outages and, depending on the type of power purchase agreement, vulnerable to price fluctuations.

3.3 Tribal Utility Independent of the Grid

If energy independence is a strong goal for Viejas, a utility could be established that would be capable of providing all generation needs independent of the outside grid. A connection would likely still be in place, but an outage or a cost of energy increase on the grid would not translate into either outage or dramatically increased cost of energy on the reservation.

In this ambitious scenario, sufficient generation, storage, and load diverting capability would need to be in place to balance generation and loads on site in absence of the support of the grid. Additional power quality equipment would likely be required. The main advantage of this scenario is self sufficiency, security, and self reliance. Viejas could still maintain the ability to interact with the grid to buy and sell power, but this would not be required.

A bigger investment with lower return would be required to meet the self sufficiency goal of this scenario as compared to the interactive utility scenario. In addition to power quality equipment reliability would require redundant generation. Furthermore the generation profile would, by necessity, be heavy on firm or dispatchable generation, such as thermal generators (fossil or renewable fueled), as opposed to the variable energy sources such as solar and wind, unless significant energy storage is added.

4.0 Detailed Viejas Energy Profile

4.1 Customer Load Profile

The number of customers that the Tribal Utility would potentially provide electric services to was estimated using customer data provided by the Viejas Tribal Government. Table 4-1 is a summary of the Tribal Utility's customer breakdown.

Number of Customers	
Residential	175
Percent of Total	61%
Casino	50
Percent of Total	18%
Tribal Offices/Facilities	10
Percent of Total	4%
Retail Outlet	50
Percent of Total	17%
Total	285

Table 4-1. Customer Breakdown.

Due to the resistance in electrical power transmission and distribution lines, a certain amount of power is lost from a generating facility to where the power is finally consumed. The annual loss factor is assumed to be 6.18 percent. This figure is in-line with industry averages. Viejas will have to account for these losses and purchase additional power at the transmission grid to ensure adequate power for its customers. The total energy used in this report's analysis is 24,018,539 kWh for 2005. The annual escalation of energy is assumed to be 1.70%.

Hourly load data for the year 2003 was acquired for Viejas' large customers from SDG&E. This data was used to generate an hourly load profile for these customers located within Viejas land. For residential customers, assumptions were developed by applying hourly residential load profiles for a comparable California utility to the number of residential customers on Viejas land. Figure 4-1 shows the average hourly energy usage for 2003 for the aggregate Viejas load.

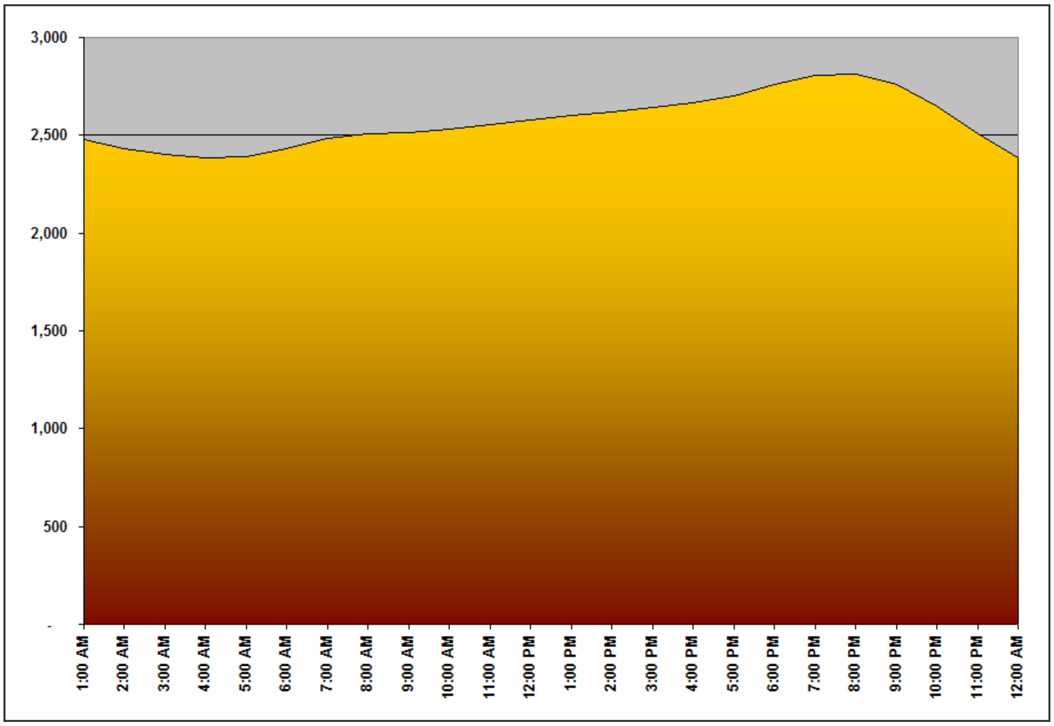

Figure 4-1. Daily Average of Hourly Viejas Energy Usage

4.2 Projected Peak Demand

Another key element in determining the Tribal Utility's cost of power is determining the peak electric demand that occurs on the Tribal Utility's system. Black & Veatch has estimated the Tribal Utility's annual energy sales and the system load factor using results from the Energy Assessment Study performed by Black & Veatch in 2002. Table 4-2 shows the forecasted Peak Demand and Annual Energy Usage for the years 2005 through 2026. Peak Demand and Annual Energy are assumed to escalate at 1.70% per year.

Table 4-2. Annual Demand and Energy Forecast.

Year	Peak Demand	Annual Energy Usage
2005	5,217	24,018,539
2006	5,306	24,426,855
2007	5,396	24,842,111
2008	5,488	25,264,427
2009	5,581	25,693,922
2010	5,676	26,130,719
2011	5,772	26,574,941
2012	5,871	27,026,715
2013	5,970	27,486,169
2014	6,072	27,953,434
2015	6,175	28,428,643
2016	6,280	28,911,929
2017	6,387	29,403,432
2018	6,495	29,903,291
2019	6,606	30,411,647
2020	6,718	30,928,645
2021	6,832	31,454,432
2022	6,949	31,989,157
2023	7,067	32,532,973
2024	7,187	33,086,033
2025	7,309	33,648,496
2026	7,433	34,220,520

4.3 Hourly Load Profile

Hourly load data for the year 2003 was acquired for Viejas' large customers from SDG&E. This data was used to generate an hourly load profile for the customers located within Viejas land. Figure 4-1 shows the daily average energy usage by hour for 2003. This hourly load profile is an important assumption used in the generation optimization model, and serves as the basis for dispatching generation using Black & Veatch's production cost model, POWRPRO. The optimization model and POWRPRO are described in Section 10.0.

5.0 Renewable Energy Alternatives

5.1 Wind

Wind power systems convert the movement of the air to power by means of a rotating turbine and a generator. Wind power has been the fastest growing energy technology of the last decade. It has realized around 30 percent annual growth in worldwide capacity for the last five years. Cumulative worldwide wind capacity is now estimated to be more than 39,000 MW. Europe now leads in wind energy, with more than 28,000 MW installed; Germany, Denmark, and Spain are the leading European countries. Installations of wind turbines have outpaced all other energy technologies in Europe for the past two years.

In the US, the American Wind Energy Association (AWEA) has noted that wind turbine capacity exceeded 6,000 MW at the start of 2004. The booming US wind market has been driven by a combination of growing state mandates, such as that in place for California, and the production tax credit (PTC), which provides a 10-year 1.8 cent/kWh incentive for electricity produced from wind. The PTC is active through the end of the year 2007. Over 2,000 MW are expected to be installed in 2005.

Typical utility-scale wind energy systems consist of multiple wind turbines that range in size from 0.6 MW to 2 MW. Typical wind energy system installations may be as small as 0.6 MW or as large as 300 MW. Single and small groupings of turbines are common in Denmark and Germany whereas installation of large wind farms is more typical in the United States. However, use of single turbines is increasingly common in the United States for powering schools, farms, factories, water treatment plants, and other distributed loads. At the other end of the spectrum, off-shore wind energy projects are now being planned, which is encouraging the development of both larger turbines (up to 5 MW) and larger wind farms.

Wind is an intermittent resource with average capacity factors usually ranging from 25 to 40 percent. Capacity factor is the percent of energy produced in a year compared to what the generator would produce if it were running at full output all year. The capacity factor of an installation depends on the wind regime in the area and energy capture characteristics of the wind turbine. Capacity factor directly impacts economic performance, thus reasonably strong wind sites are a must for cost effective installations.

Figure 5-2. A small wind farm in Hawaii

Figure 5-3. The Palmdale Water District Net Metered Wind Turbine.

Because wind is intermittent it cannot be relied upon as firm capacity. To provide a dependable resource, wind energy systems may be coupled with some type of energy storage or a fossil energy source to provide power when required by the load. This adds considerable expense and is not usually done on a without special circumstances. Numerous studies have shown that, within a typical utility, relatively low levels of wind penetration 5-15% will not necessitate significant additional backup generation or other system improvements. Efforts are currently underway by research agencies to forecast wind speeds more accurately, thereby increasing confidence in wind power as a generation resource and dependability in utility dispatching.

Wind is created primarily by global temperature fluctuations and thermal interactions between land, sea, and air. Wind energy systems convert the power of moving air into electricity. Aerodynamic forces act on the rotor to convert the linear motion of the wind stream into the rotational motion needed to turn an electrical generator. The available power in the kinetic energy of the wind is given by the relation:

$$P = \tfrac{1}{2}\rho A V^3$$

where ρ is the air density, A is the rotor area intercepting the wind, and V is the upstream wind velocity. Of these, wind velocity is most important. The cubic dependence of wind power on wind speed implies that energy output, and consequently the economics of a wind turbine installation, is highly sensitive to wind speed. A 50 percent change in velocity results in more than tripling available energy; thus wind speed is one of the most critical factors in determining wind energy generation. Wind power density is expressed in Watts per meter squared (W/m^2) and incorporates the combined effects of the time variant wind speed and the dependence of wind power on both air density and cube of wind speed. The figures in this report show wind power density categorized by wind power class from 0-7.

Average wind speeds vary significantly geographically. Local factors such as high altitude, unobstructed terrain, lofty airflow height, and natural wind tunneling features cause some areas to have inherently higher wind speeds on average than others. Wind speed is affected by the height above ground level (AGL). Ideally, wind resources assessments are performed at the hub height of the candidate wind turbine (40 to 80 m); however, if measurements at the actual hub height (Z) are not available, wind speed (v) can be extrapolated from other measurement heights. The most common method is the following relation, known as the one-seventh power law:

$$\frac{v_2}{v_1} = \left(\frac{Z_2}{Z_1}\right)^{1/7} \quad or \quad \frac{P_2}{P_1} = \left(\frac{Z_2}{Z_1}\right)^{3/7}$$

For example, based on the one-seventh power law, wind speed and wind power (P) at 30 m above the ground are respectively 17 and 60 percent greater than at 10 m. Although a convenient approximation, the one-seventh power law has no theoretical basis. A custom power law can be applied to a specific site data by measuring wind speed at two or more different heights on the same tower and determining the wind sheer factor (s) for a specific site. Once a sheer factor is known for a site, wind speed can be scaled using the following equation:

$$v_2 = v_1 * \left(\frac{Z_2}{Z_1}\right)^{S}$$

The site-specific nature of the wind energy resource underscores the need for well-planned assessments. The one-seventh power law may be inadequate because it is only an approximation and the amount of wind energy available is strongly affected by the local terrain. If the wind sheer factor for a specific site is known, a more accurate power estimate can be made from non-hub height data. A thorough study of the wind at a particular site is advisable before installing wind turbines. Collecting data at multiple hub heights and locations allows for the optimum design and placement of individual turbines in large turbine arrays or on complex terrain. In this report, a wind sheer factor was estimated based on the local topography and measurements made at ten and twenty meters above ground level.

The site wind resource is of critical importance to a wind project because it is the fuel for the power plant. Wind generation suffers in notoriety because it is intermittent – subject to the strength and consistency of the wind. Because of this, the best way to ensure a successful project is to collect as much data as possible and make informed decisions at every step of the project development. This data should be compared against historical data for the area for the longest possible time span that data can be obtained.

For the purposes of this study, the wind resource has been evaluated using Data collected at two sites on the reservation for a period of a year. The data from these sites did not correlate well with publicly available long term data from Campo, CA, Palm Springs, CA, nor any other nearby public data source. The Manzanita Band of the Kumeyaay tribe has been collecting wind data for several years for their own wind energy project. Black & Veatch has contacted the Manzanita Band to obtain access to this data, however access has not yet been granted.

5.1.1 Resource Availability

Wind speed increases significantly with height above ground, and wind turbine power output rises with the cube of wind speed, which makes small differences in wind speed very significant. As shown in Table 5-1 wind strength is rated on a scale from Class 1 to Class 7. Wind speeds and power densities (W/m^2) at a Class 1 site and at a 50 meter height can go as high as 5.5 m/s and 200 W/m^2. In comparison, wind speeds and power densities at a Class 7 site and at the same hub height may be above 8.80 m/s and approach 1000 W/m^2. Class 3 sites and higher are usually considered for wind project development, although possibly Class 2 sites also may be viable for self generation, depending on the cost of electricity.

Regardless of the existence of high resolution resource maps for some regions, a minimum of one-year of site data collection is typically required to determine if utility-scale wind energy is viable at a specific location. Wind speeds around the Viejas reservation from the California wind map data published by the National Renewable Energy Laboratory and prepared by Black & Veatch can be seen in Figure 5-4. Wind map data is considered accurate to within one wind class.

Table 5-1. US DOE Classes of Wind Power.

Wind Power Class	Height Above Ground: 50 m (164 ft)*	
	Wind Power Density, W/m^2	Speed** m/s
1	0 – 200	0 – 5.60
2	200 – 300	5.60 – 6.40
3	300 – 400	6.40 – 7.00
4	400 – 500	7.00 – 7.50
5	500 – 600	7.50 – 8.00
6	600 – 800	8.00 – 8.80
7	800 – 2000	8.80 +

Notes:
* Vertical extrapolation of wind speed based on the 1/7 power law.
** Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density. Wind speed is for standard sea-level conditions. To maintain the same power density, wind speed must increase 3%/1000 m (5%/5000 ft) elevation.

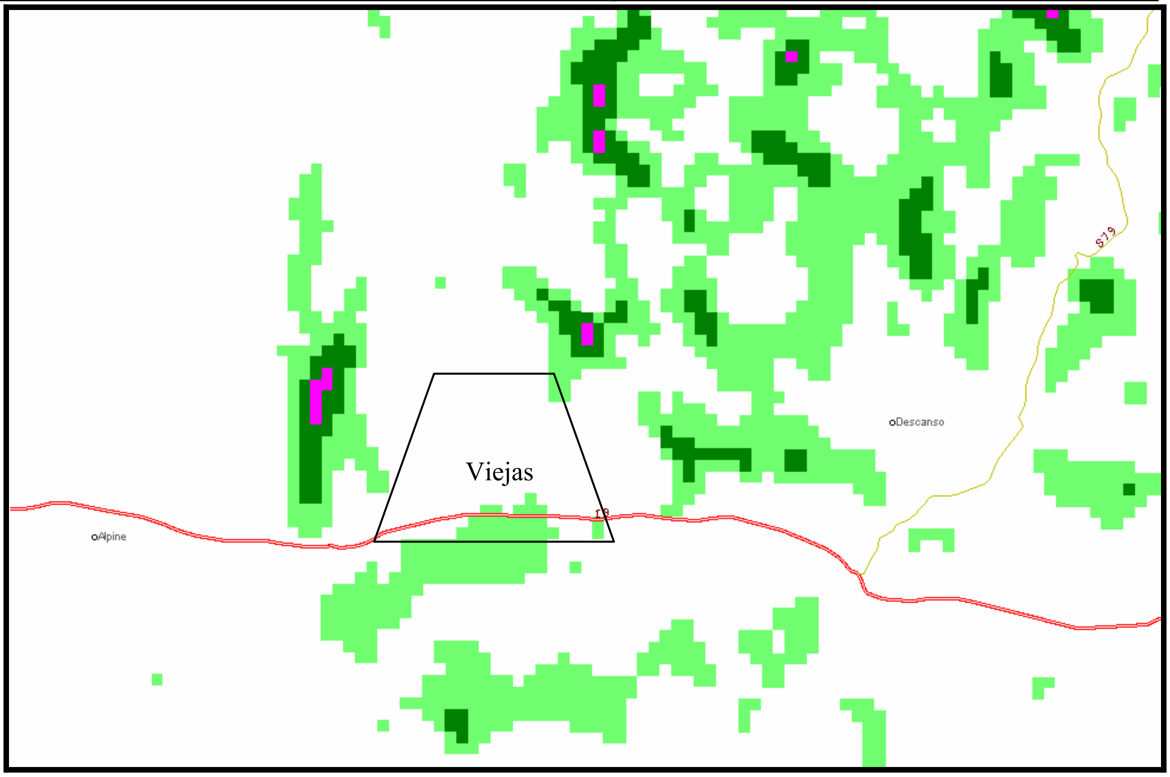

Figure 5-4. Close up of the California Wind Map Around Viejas.

Figure 5-4 Shows the wind map for California around the area of Viejas. Light green indicates Wind Class 2, dark green is Wind Class 3, and Fuchsia shows wind class 4.

5.1.1.1 Cost and Performance Characteristics

Table 5-2 provides typical characteristics for a 50 MW wind farm and a single 1 MW turbine for distributed applications. Substantially higher costs are incurred by wind projects that require upgrades to transmission and distribution lines. Capacity factors for the two sample projects have been chosen to correlate with those expected for a wind farm on the Capitan Grande Reservation and a net metered turbine at the casino.

Table 5-2. Wind Technology Characteristics.

	Wind Farm	Distributed
Performance		
Typical Duty Cycle	As Available	As Available
Net Plant Capacity, MW	50	1
Capacity Factor, percent	20-30	8-13
Economics		
Capital Cost, $/kW	1,600	700 *
Fixed O&M, $/kW-yr	15	18
Levelized Cost, $/MWh	70	90
Technology Status		
Commercial Status	Commercial	
Installed US Capacity, MW	6,740	
Viejas Potential	Fair	

* Includes $1500/kW SGIP Incentive

Capital costs for new onshore wind projects have remained relatively stable for the past few years and have increased recently with the cost of steel. The greatest success in reducing cost of energy have been made by identifying and developing sites with better wind resources and improving turbine reliability. These both lead to improved capacity factors. The average capacity factor for all installed wind projects in the US has dramatically increased, from just 20 percent in 1998 to more than 30 percent in 2002.[1]

5.1.2 Site Assessment / Selection

Two sites were selected at Viejas for wind data collection. The sites are shown on the map in Figure 5-6. The site labeled Master was chosen due to its central location and plentiful open space for siting future wind turbines. The Master anemometer is intended to be the future reference site to correlate any future wind data collection sites and to collect long term data. The site labeled Casino was chosen as an alternate measurement point in a location selected to take advantage of any acceleration of wind into the Viejas valley. The Casino location would be a potential site for a single turbine interconnected with the Casino.

[1] Based on annual wind generation and capacity data from the Energy Information Administration's *Renewable Energy Annual 2002*.

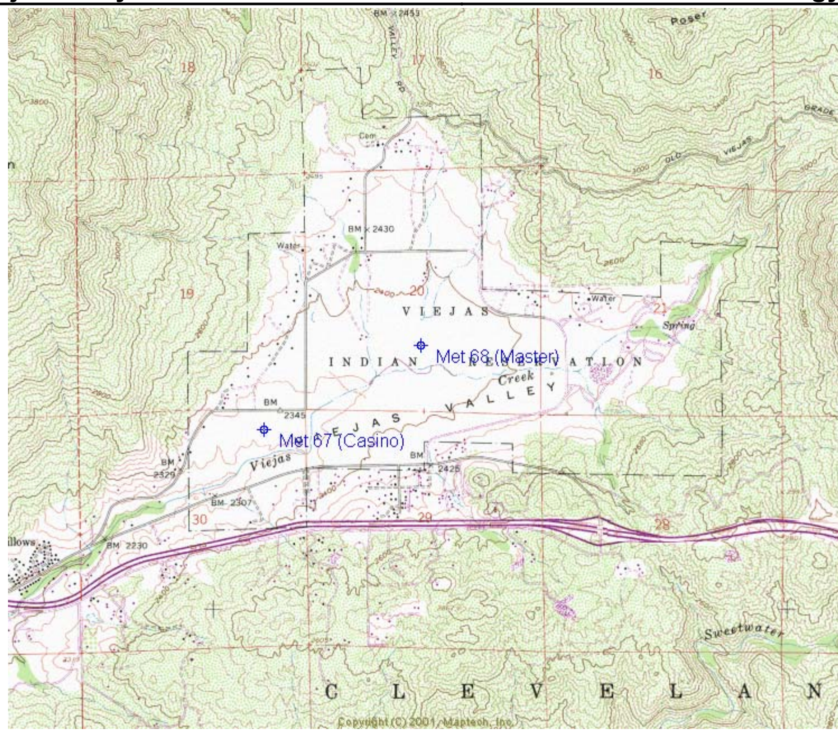

Figure 5-5. Location of Wind Monitoring Equipment at Viejas.

5.1.3 Wind Data Collection

Data was collected at both sites using an NRG 20 meter tower and an NRG 9200-Pluss Data logger. Anemometers were placed at 10 and 20 meters above ground level, and wind direction was measured at 20 meters above ground level. Data was averaged in date-and-time-stamped ten-minute intervals. Data sticks were exchanged monthly and the data was uploaded in the Viejas Tribal Government public works office. Data was then emailed to Black & Veatch, where it was conditioned and analyzed. This report uses data collected from 8:30 am March 3, 2004 till 8:20 am March 3, 2005. Data was missing for both sites simultaneously for a total of 62 days, primarily in November, December, and January. Data loss in November is likely due to a nearby lighting strike, disabling both data loggers. An attempt to fix the problem was made but Data from both loggers was lost in the last half of December. Additional data was lost while both loggers were in for repair in January. Data loss problems have continued at a less severe level and the cause is not understood at present. Where data was missing from only one site Black & Veatch established correlation factors between the two sites and filled in the missing data using data from the site with good data.

Table 5-3 provides a catalogue of significant periods of lost data.

Table 5-3. Missing Data			
Start Date	**End Date**	**Data Capture**	**Days**
3/3/04 8:40	4/29/04 3:30	Good Data	57
4/29/04 3:30	5/5/04 13:10	Missing Data	6
5/5/04 13:10	11/4/04 9:10	Good Data	183
11/4/04 9:10	12/2/04 17:20	Missing Data, Possible Lightning Strike	28
12/2/04 17:20	12/6/04 7:20	Good Data	4
12/6/04 7:20	12/13/04 14:00	Master fills in Casino	7
12/13/04 14:00	12/17/04 11:20	Good Data	4
12/17/04 11:20	1/3/05 9:10	Missing Data	17
1/3/05 9:10	1/7/05 8:30	Master fills in Casino	4
1/7/05 8:30	1/20/05 13:10	Missing Data, Loggers in for repair.	13
1/20/05 13:10	1/28/05 8:40	Good Data	8
1/28/05 8:40	2/25/05 18:20	Casino fills in Master	28
2/25/05 18:20	3/1/05 8:20	Good Data	4
3/1/05 8:20	3/29/05 18:20	Casino fills in Master	28
3/29/05 18:20	4/4/05 8:20	Good Data	6
	Totals:	Good Data	264
		Missing Data	65
		Filled data	68

5.1.4 Wind Data Analysis

Wind Data was received monthly and given summery analysis at that time. This preliminary analysis ensured that the data was being collected properly, and also gave an indication of the resource for the month. When a year of data was available, the following steps were used to process that data. Initially, a wind speed ratio was set up between the two meteorological towers for correlating data between the two. This correlation was used to fill in data from one met site to the other for periods of time when one had data and the other did not. There were 68 days where data was only available from one anemometer. For 65 days data was not collected by either anemometer. One option for dealing with the lack of data is to assume the data for the rest of the year is representative and use a typical sample of that data to represent the missing period. Unfortunately these 65 days were mostly in November, December, and January, when Viejas expects to receive the strong Santa Ana winds. An attempt was made to represent this by using data from October, December, January, and February around the periods of lost data to fill in the blanks. The disadvantage of the technique used is that data collected around the voids is double counted and, in the case of the period December 2 through 17, triple counted. If this data is not representative, it has a disproportionate skewing effect on the analysis. Results of the analysis using this technique show a significant increase in annual energy production compared to using only the data collected. These results have increased uncertainty caused by the missing data.

The annual data set once established was scaled for annual variations based on long term data. The long term data available from Campo, CA, and Palm Springs, CA, although having poor correlation with the anemometer at Viejas, is sufficient to give a sense of annual wind variations in the region. Both of these sites showed that 2004 was a slow wind speed year by about ten percent compared to an 8 year average. Thus the wind speeds measured at Viejas were scaled upward by ten percent to represent a 'typical' year. These typical year wind speed values were then used in Black & Veatch's wind turbine model.

The turbine model first scales wind speeds to a selected turbines hub height using the wind shear exponent measured at the site or assumed by terrain. At Viejas a wind shear exponent of 0.1 was measured from the difference between wind speeds at ten meters and wind speeds at twenty meters. The turbine model then separates the scaled wind speeds into 1 m/s bins. For example, wind speeds from 4.5 m/s to 5.5 m/s are all placed into the 5 m/s bin. These binned wind speeds are then combined with a wind turbine manufacturers published power curve to give annual power output. Two likely turbines were selected for this analysis both having a rating of 950 kW, the Vestas NM54 and the Suzlon S64. The Suzlon turbine is designed for slow wind speeds, and out-performed the Vestas turbine on an energy capture basis. Energy capture is not the only factor in selecting a turbine. Cost and maintenance are also key factors. Losses were assumed to be five percent, to account for blade soiling, turbulence, electrical, and other losses.

Of the two anemometry sites, the Casino site was chosen to perform the detailed analysis of evaluating a single turbine project. Such a project would likely be net metered through one of the casino utility meters, and thus a location near the casino is appropriate. Furthermore, the Casino site has the more complete data set of the two. Data analyzed from the Master site yields very similar results to those shown for the Casino site.

A wind power and frequency of occurrence rose is shown in Figure 5-6. The graphic clearly shows that winds at this site are almost exclusively from the northeast or the southwest. This makes sense because the site is located in a valley of similar orientation, and because of the east-west coastal wind regime of the area. Good exposure to the wind in each of these directions is critical for maximum energy capture.

Conversely obstacles outside of these directions can be quite prominent without having a significant impact on energy capture.

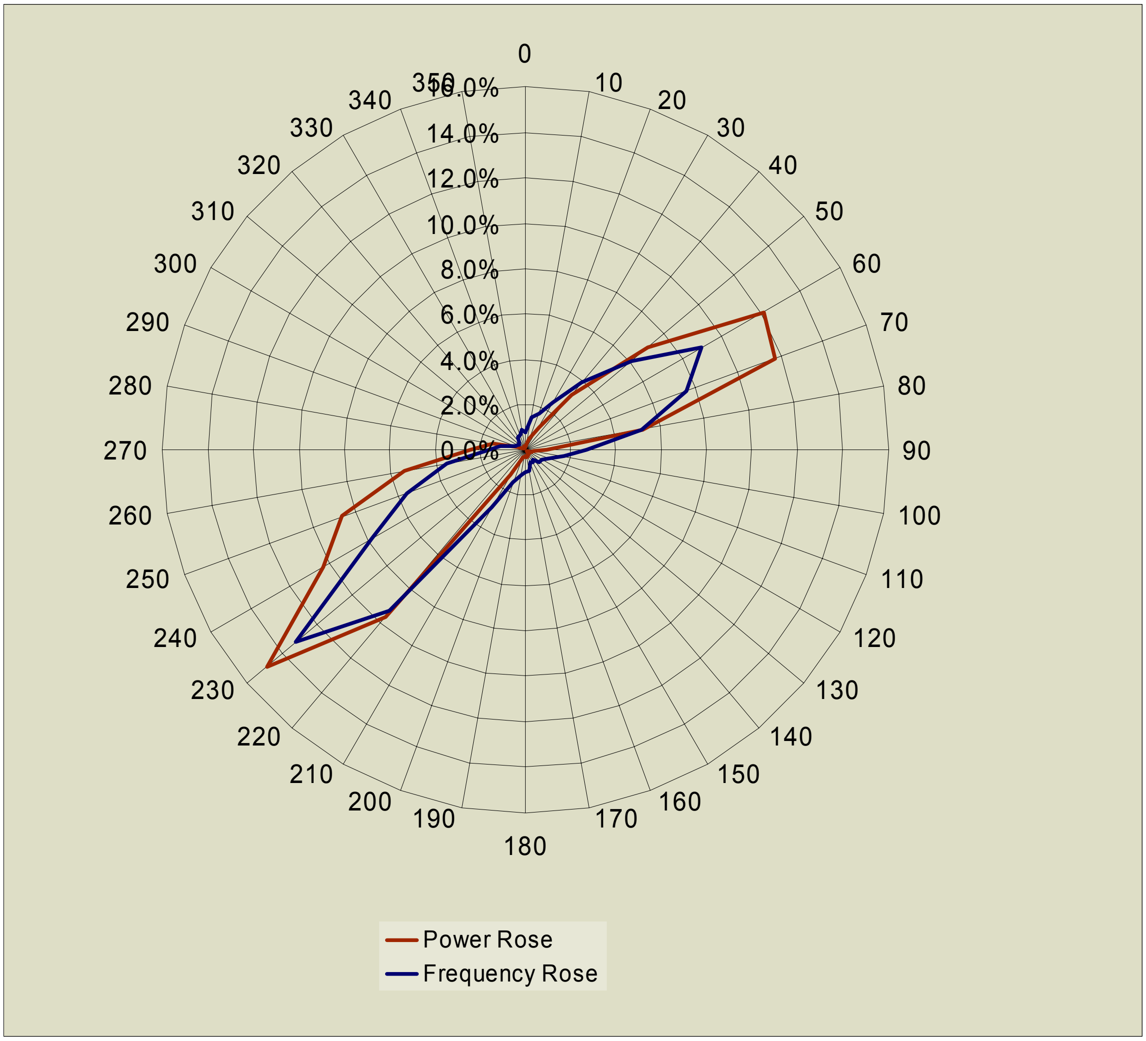

Figure 5-6. Wind Rose for Casino Site.

Figure 5-7 shows the annual average daily distribution of wind power production. The Viejas valley has a strong afternoon peak in power production. This peak corresponds well to the summer peak power pricing period between 11 am and 6 pm. As can be seen in the figure, almost 60 percent of wind power generation occurs over these seven hours.

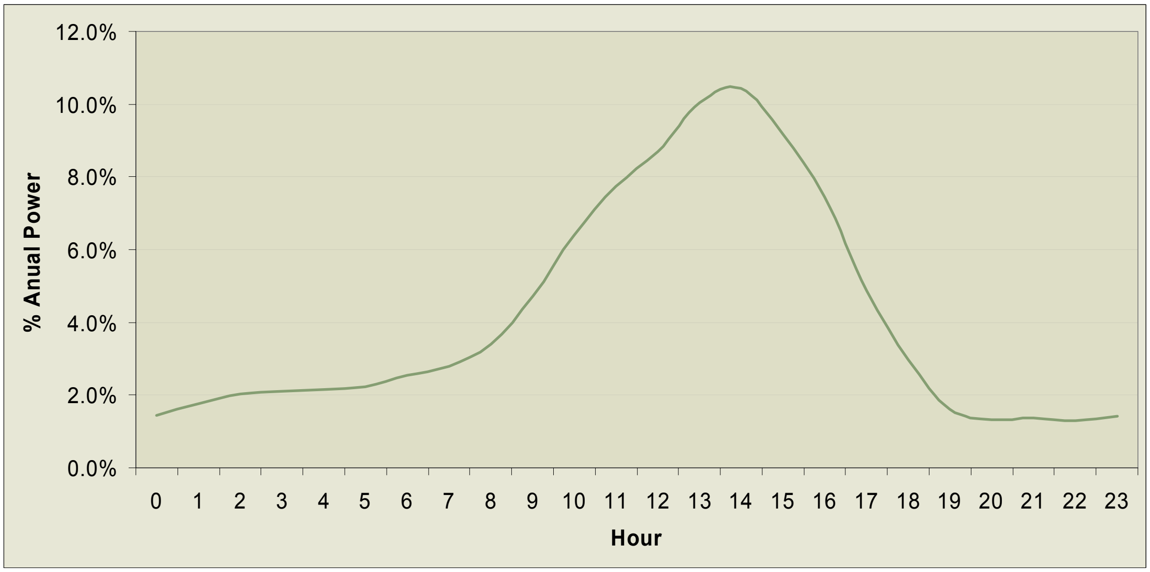

Figure 5-7. Power Production by Time of Day.

Figure 5-8 shows the theoretical power output by month for the measured year. It should be noted that almost none of November, and only half of December and January were actually recorded due to data logger failures. These data were estimated by repeating data from earlier or later periods and may not be representative. Due to the uncertainty of the winter months' data, poor correlation to known sites, and only one year of measurement, it is not clear what seasonal pattern to expect.

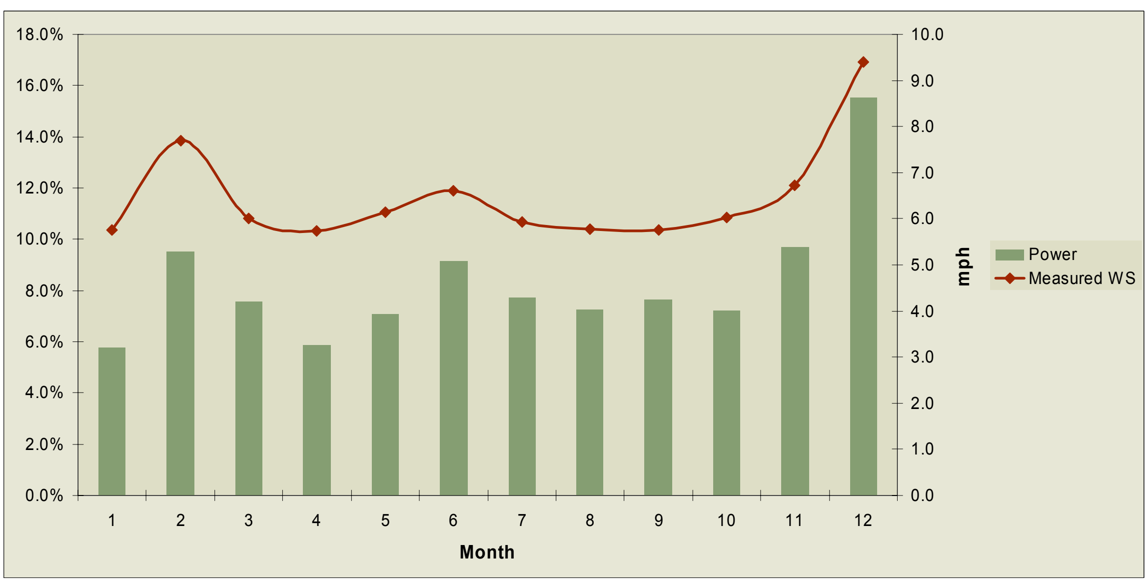

Figure 5-8. Monthly Power Output.

Figure 5-9 shows the power curve for a Suzlon S64 950 KW wind turbine plotted in red. The actual wind speed frequency distribution for the year measured is represented by green bars. It can be seen that much of the time wind is slower than the 3 m/s cut in wind speed of the turbine. The blue line shows that most of the energy is produced at modest wind speeds between five to ten meters per second. This highlights the importance of selecting a turbine designed for low wind speed performance.

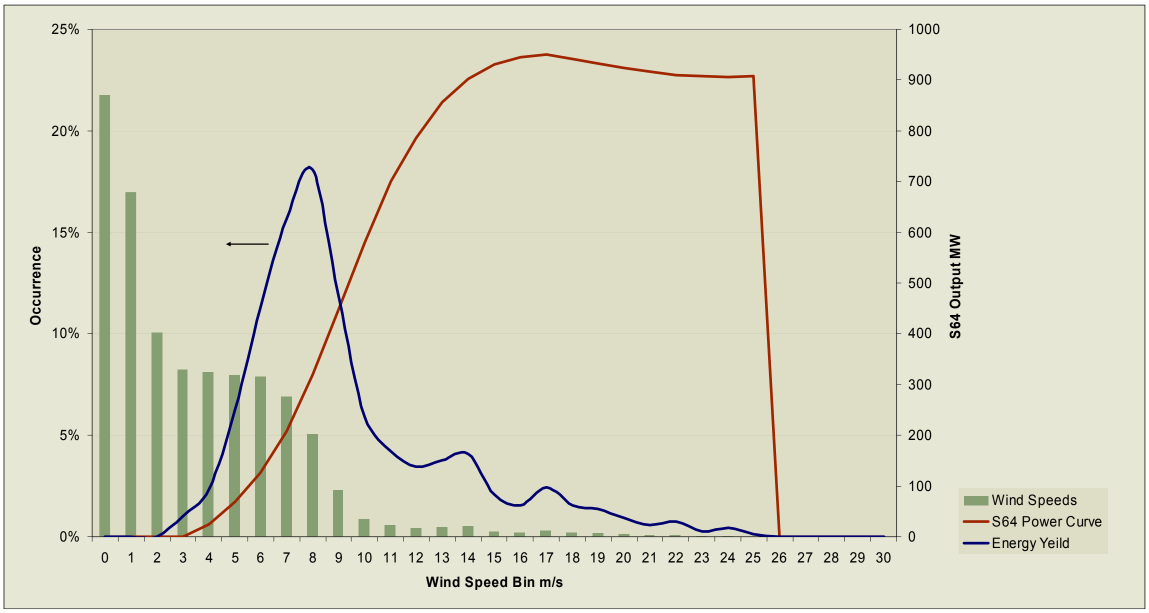

Figure 5-9. Casino Wind Speed Distribution.

Using the above described method, a capacity factor of 12.7 percent was predicted for the Casino site using a Suzlon S64 950 kW turbine at 60 meter hub height. This gives an annual energy yield of 1,100 MWh. Using the Vestas NM54 950 kW turbine at 60 meter hub height, a capacity factor of 9.5 percent was predicted with an annual energy yield of 840 MWh. It should be noted that due to the relatively low height above ground level of data collection, missing data, and poor correlation with historical wind data the above estimated capacity factors have a fairly high level of uncertainty. The main reason for the difference in capacity factors for the two turbines is the Suzlon turbine has a 64 meter diameter rotor and the Vestas rotor is 54 meters in diameter. Though the turbines have the same kilowatt rating, their output at low wind speeds is very different due to the amount of swept area of the blades. Energy yield is not the only factor in selecting a turbine. Capital cost, maintenance requirements, and other factors have a strong impact.

Time of Energy production was analyzed for the Suzlon turbine scenario to investigate the value of energy produced. Value was based on the time of use rates the Viejas Casino is currently on. Using rates most prevalent during the period studied, it is estimated a Suzlon S64 turbine would have generated $83,000 in savings for the March 2004 to March 2005 period. If the year had been one with typical winds $103,000 would have been saved from the single turbine according to B&V Analysis. The SDG&E ALTOU electrical rate recently decreased by about $5/MWh from those used to obtain the above dollar figures.

It should be noted that the average annual energy yield estimates are based on data collected significantly below hub height, in a low wind speed year, with some large gaps in the data set. The assumptions used to fill in the gaps of the data, adjust to hub height, and to represent a typical year have a very strong effect on the estimate. While these assumptions were made using industry recognized techniques this does not eliminate the significant uncertainty of the results. Data is continuing to be collected and long term data may become available from the Manzanitas Band of Kumeyaay Indians. If the economics of proceeding with a single turbine project are marginal this additional data should be evaluated and an uncertainty analysis performed to aid in decision making.

Data was also input into wind industry software WASP ™ and WindFarmer ™ to model wind speeds across the Viejas area.

Figure 5-11 below is a map of the Viejas and Capitan Grande reservation areas and relative wind power densities. Red and fuchsia areas indicate the highest wind power density, while light blue indicates the lowest. Because measured data is only from the valley floor the usefulness of the model is restricted to only give a rough estimate of wind conditions at higher elevations in the surrounding area. Though not suitable for planning a wind farm, this information is valuable for identifying areas to place an anemometer to gather data, and gives a general idea of the resource distribution.

Figure 5-12 shows to greater resolution the wind power densities on the Viejas valley floor. Heavy black lines indicate approximate reservation borders. The map shows that the Casino is in a higher wind area of the Viejas Reservation and that wind speeds tend to increase to the south. Note the entire region of Figure 5-12 is in the lower range of wind resource from the larger area map of Figure 5-11. The gradients on both of these wind maps are on a relative scale. This shows the variation of wind resource across the terrain and is not intended to indicate a specific wind class.

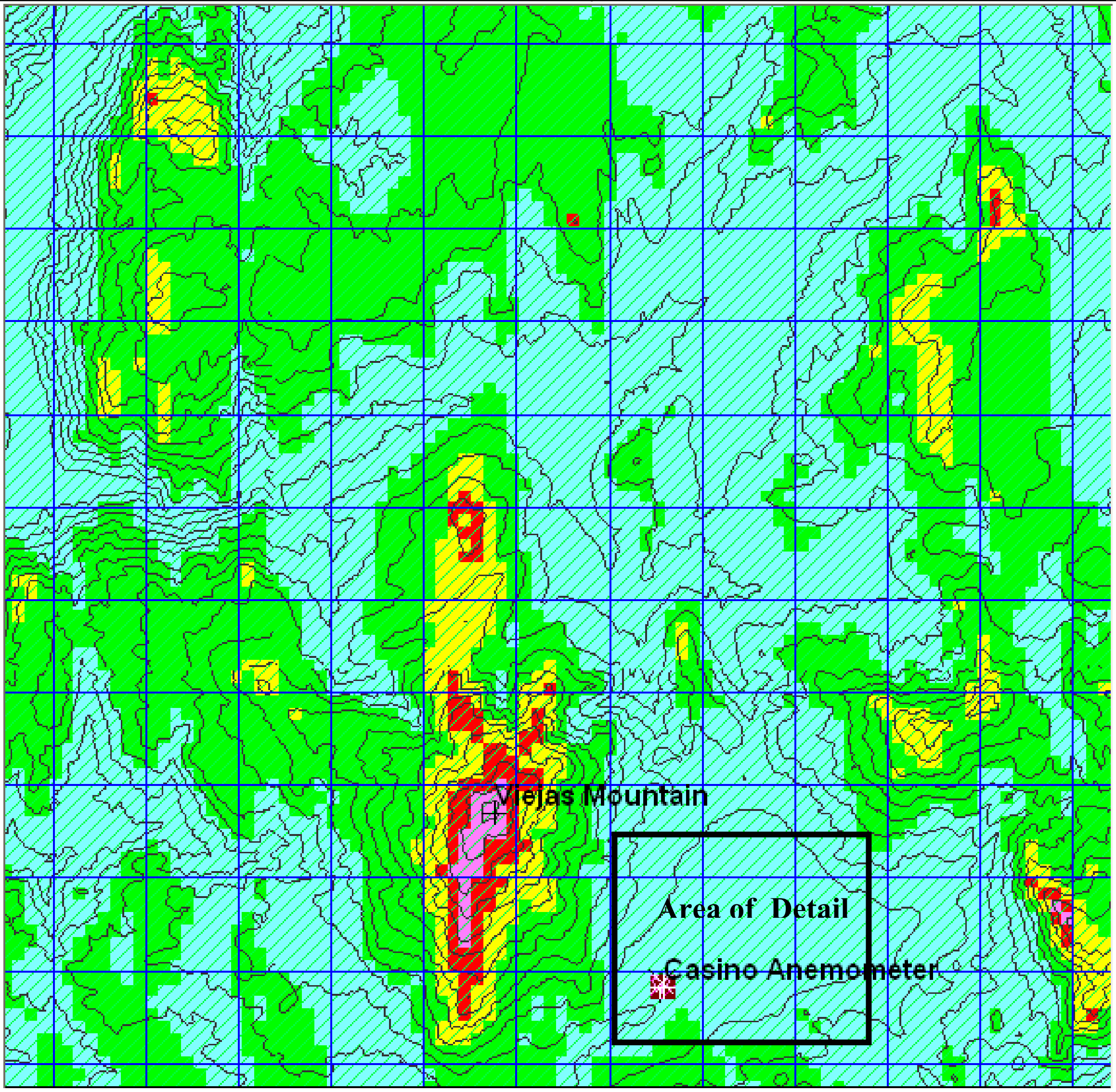

Figure 5-10. Wind Resource Gradient, Viejas and Capitan Grande

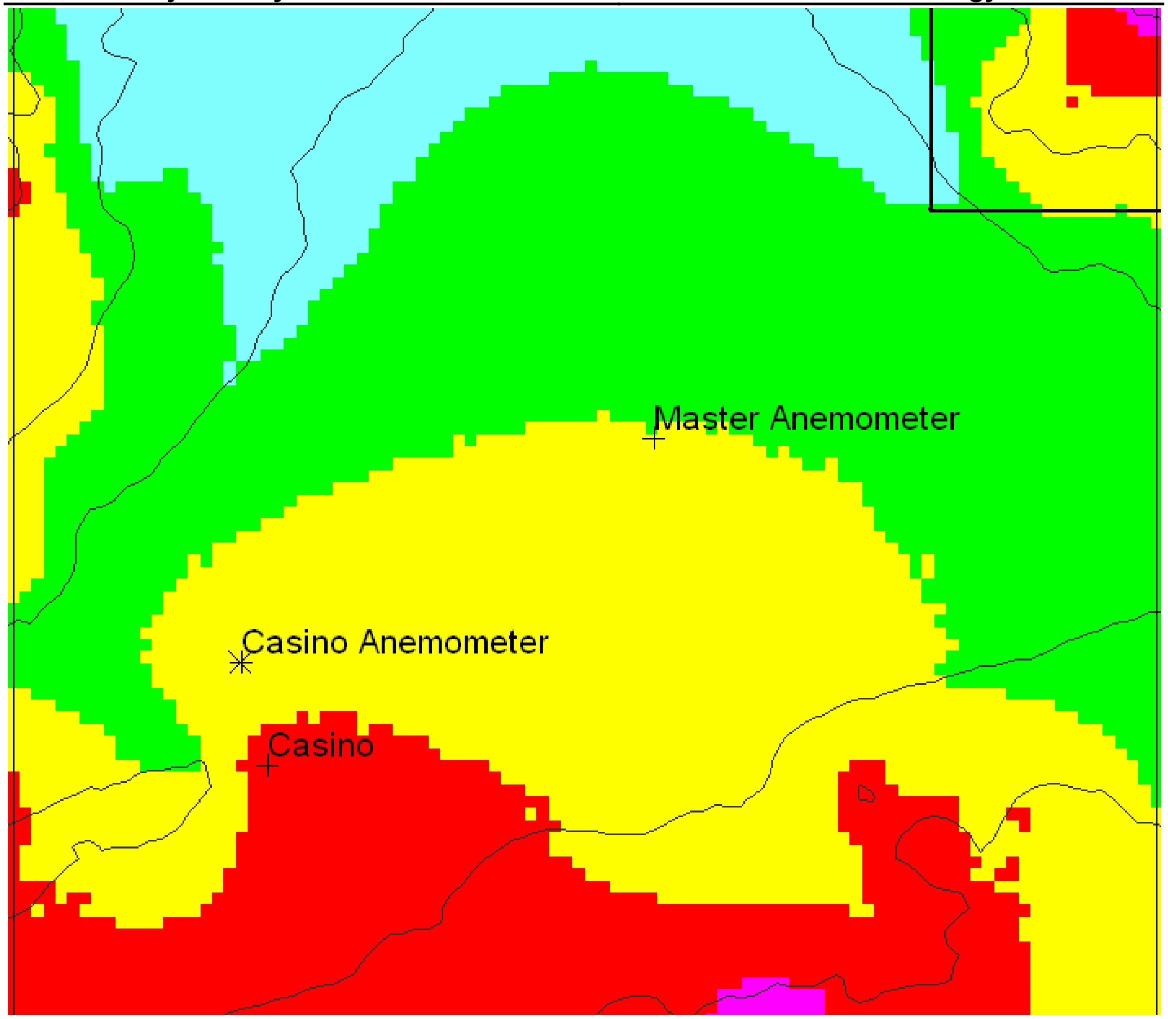

Figure 5-11. Wind Resource Gradient, Viejas Valley Floor.

5.2 Solar thermal

5.2.1 Technical Description

Solar thermal technologies convert the sun's energy to productive use by capturing heat. Early developments in solar thermal technology focused on heating water for domestic use. Advances have expanded the applications of solar thermal to high magnitude energy collection and power conversion on a utility scale. Numerous solar thermal technologies have also been developed over the past three decades as potential sources of renewable power generation. The leading technologies currently include parabolic trough, parabolic dish, power tower (central receiver), and solar chimney. Solar hot water heating is a developed and economical technology and could be considered as a part of a load reduction program.

Figure 5-12. Parabolic Trough Field (Source: Union of Concerned Scientists)

With adequate resources, solar thermal technologies are appropriate for a wide range of intermediate and peak load applications including central station power plants and modular power stations in both remote and grid-connected areas. There is currently 350 MW of solar thermal parabolic trough plants installed in California.

Figure 5-13. Solar Two Central Receiver Installation

Solar trough and solar tower systems transfer the heat in solar radiation to a heat transfer fluid, heat transfer oil or molten salt, respectively. A heat exchanger converts the energy in the heat transfer fluid to steam, which is subsequently used to power a steam turbine. Solar thermal technologies may be combined with co-utilization of fossil fuels or energy storage to provide a dependable dispatchable resource. A thermal storage tank can be used to store hot heat transfer fluid, providing thermal energy storage. By using thermal storage or by combining the solar system with a fossil-fired system (a hybrid solar/fossil system), a solar thermal plant can provide dispatchable electric power. Parabolic dish systems use hydrogen as a working fluid to capture the solar heat and power a Stirling cycle engine. Energy storage is not an option for any pre-commercial parabolic dish systems.

Solar chimneys do not generate power using a thermal heat cycle as the other three technologies do. A solar chimney plant is essentially a tall chimney located in the center of a large greenhouse. As the air in the greenhouse is heated by the sun, it rises and enters the chimney. The natural draft produces a wind current, which rotates a collection of wind turbines in the chimney. The first commercial solar chimney is currently under development in Australia.

5.2.2 Applications

The larger solar thermal technologies (parabolic trough, central receiver and solar chimney) are currently not economically competitive with other central station generation options (such as natural gas combined cycle). Parabolic dish engine systems are small and modular and can be placed at load sites, thereby directly offsetting retail electricity purchases. However, these systems are still under development and do not have a long track record in commercial applications.

Figure 5-14. Parabolic Dish Receiver (Source: Stirling Energy Systems).

Parabolic trough represents the vast majority of installed solar thermal capacity. There are nine SEGS (Solar Electric Generating Station) parabolic trough plants in the Mojave Desert that have a combined capacity of 354 MW. These plants were installed from 1985 to 1990 and have been in continual operation since that time. Other parabolic trough plants are being developed, including a 50 MW plant in Nevada. Small parabolic dish engine systems have been developed and are now being actively marketed. These dishes are typically about 25 kW in size. The US government has funded two utility-scale central receiver power plants: Solar One and its successor/replacement, Solar Two. Solar Two was a 10 MW installation near Barstow, California, which is no longer operating due to reduced federal support and high operating costs. A project is proposed in Australia to build a 200 MW solar chimney. The estimated cost is $700 million and would include a chimney one kilometer (0.62 mi) tall with an accompanying greenhouse 5 km (3.1 mi) in diameter.

5.2.3 Resource Availability

Concentrating solar thermal systems (troughs, dishes, and central receivers) use direct normal insolation. Lower latitudes with minimum cloud cover offer the greatest solar concentrator potential. An advantage of solar thermal systems, and generally all solar technologies, is that peak output typically occurs on summer days when electrical demand is high. Solar thermal systems with storage provide a dispatchable resource which can improve matching plant output to load requirements.

5.2.4 Cost and Performance Characteristics

Representative characteristics for the four solar thermal power plant technologies are presented in Table 5-4.

Table 5-4. Solar Thermal Technology Characteristics.

	Parabolic Trough	Parabolic Dish	Central Receiver	Solar Chimney
Performance				
Typical Duty Cycle	Peaking - Intermediate	As available, Peaking	Peaking - Intermediate	Intermediate - Baseload
Net Plant Capacity, MW	100	0.025	50	200
Integrated Storage?	12 hours	No	16 Hours	Yes
Capacity Factor, percent	40-55	20-25	60-80	60-80
Economics				
Capital Cost, $/kW	5,200-6,500	3,900-5,200	6,500-9,100	4,600-5,900
Variable O&M, $/MWh	33-39	13-26	13-26	13-26
Levelized Cost, $/MWh	133-164	150-350	115-133	87-99
Technology Status				
Commercial Status	Early Commercial	Demonstration	R&D	R&D
Installed US Capacity, MW	~350	< 1	10*	< 1
Viejas Potential	Fair	Moderate	Poor	Poor

* No longer operating

5.2.5 Suitability to Viejas

A large experimental central receiver or solar chimney plant would not be suited well to providing power to Viejas because of the high risks associated with these technologies. It is conceivable that at a future date a parabolic trough plant could be constructed to produce power for both internal use and power sales. This could be attractive due to the energy storage capability of a solar trough system. The economical size of a solar trough power system is many times greater than the base load at Viejas so a trough system should only be considered if exporting power is a goal.

The most likely solar thermal technology for power production in the near term would be a parabolic dish system. This system can be installed incrementally 25kW at a time reducing the risk associated with this technology. The incremental nature of this technology, like photovoltaic panels, allows for systems to be sized in order to match loads in a net metering scenario. At the time of this report parabolic dish systems are not commercially available. There has been a recent rush of activity with this technology though, and there is a reasonable likelihood that within the next few years there will be a commercial product available.

Solar hot water systems are common throughout California and can be implemented on a residential as well as a commercial scale. In a solar water heating system an array of solar collectors transfer the sun's heat to the hot water system. Heat can be transferred directly to the water stream or through a heat transfer fluid such as antifreeze or heat transfer oil. A solar hot water panel utilizes 80 percent of the energy of incident sunlight to heat water compared to solar electric panels which only convert 12 percent of incident energy into electricity. Solar hot water is not specifically within the scope of this study; this technology is mentioned here because it can be the most economical solar technology. Specific performance characteristics were not investigated but as a rule of thumb, solar hot water systems tend to pay for themselves within a reasonably short period (five to ten years). Considering Viejas' good solar resource and high cost of energy, this option should be further explored as part of an integrated energy efficiency and renewable generation effort.

5.3 Photovoltaic

Photovoltaics (PV) have achieved considerable consumer acceptance over the last few years. PV module production tripled between 1999 and 2002, reaching a worldwide output of 562 MW in 2002 (the last year for which B&V has reliable data). Worldwide grid-connected residential and commercial installations grew from 120 MW/yr in 2000 to nearly 270 MW/yr in 2002. The majority of these installations were in Japan and Germany, where strong subsidy programs have made the economics of PV very attractive. Large scale (>100 kW) PV installations have been added at a rate of about 5 MW per year over the last two years.[2]

[2] Paul Maycock, "PV market update", *Renewable Energy World*, July-August 2003.

Figure 5-15. Photovoltaic Solar Panel Installation.

The amount of power produced by a PV cell depends on the materials of construction and the intensity of the solar radiation incident on the cell. Single crystal silicon cells are most widely used today. Single crystalline cells are manufactured by growing single crystal ingots, which are sliced into thin cell-size material. The cost of the crystalline material is a significant part of the cell production cost. Other methods of crystalline cell production (casting of polycrystalline material, pulling of cell-thickness ribbons) can cut material costs at some penalty to cell efficiency.

Another approach to reducing cell material cost is the development of thin film PV cells. Commercial thin films are principally made from amorphous silicon. Amorphous silicon cells suffer significant degradation and are not being seriously developed for large power applications. Copper indium diselenide and cadmium telluride thin films show promise as low-cost solar cells and are currently being researched. Thin film solar cells require very little material and can be manufactured on a large scale. Furthermore, the fabricated cells can be flexible and incorporated into building components. However, to date, thin film technology has not proven to compete on a cost effectiveness basis with crystalline silicon.

Gallium arsenide cells are among the most efficient solar cells and have other technical advantages, but they are also more costly. Gallium arsenide cells are typically used where high efficiency is regardless of cost, such as space applications.

5.3.1 Applications

The modularity, simple operation, and low maintenance requirements of solar PV make it well suited for serving distributed, remote, and off-grid applications. Most PV applications are smaller than 1 kW, although, larger utility-scale installations are becoming more prevalent. Current grid-connected PV systems are generally below 100 kW. A 3.4 MW project is currently under construction in Arizona. This is one of the largest PV installations in the world. Most grid-connected PV applications require large subsidies (50 percent or more) and/or a high cost of power to overcome high initial costs.

5.3.2 Resource Availability

Solar radiation reaching the earth's surface, often called insolation, has two components: direct normal insolation (DNI) and diffuse insolation. DNI, which comprises about 80 percent of the total insolation, is that part of the radiation which comes directly from the sun. Diffuse insolation is solar radiation that has been scattered by the atmosphere or is reflected off the ground or other surfaces. All of the radiation on a cloudy day is diffuse. The vector sum of DNI and diffuse radiation is termed global insolation. Systems which concentrate solar energy use only DNI, while non-concentrating systems use global radiation. Most PV systems installed today are flat plate systems that use global insolation. Concentrating PV systems, which use DNI, are being developed, but are not considered commercial at this time.

Generally, stationary (non-tracking) PV arrays will receive the highest average annual insolation if they are mounted at an angle equal to the latitude at which they are located. To optimize performance for winter, the array may be tilted at an angle equal to the latitude plus 15 degrees. Conversely, for maximum output during summer months the array should be tilted at an angle equal to the latitude minus 15 degrees. Single and double axis tracking systems increase the system output, but at a higher capital cost and increased O&M requirements.

Solar potential analysis on the Viejas Reservation was conducted using PV Design Pro software developed by Maui Solar Energy Software Corporation. Typical solar year data was taken from Bakersfield, California which has a similar inland foothills climate to Viejas. The difference of about two degrees latitude between the sites was compensated for by adjusting tilt angle of the solar panels appropriately. Although data from San Diego was also available which is from a closer location with similar latitude; it is the opinion of Black & Veatch that the coastal influence (e.g. morning fog) at the San Diego site did not well represent solar conditions at Viejas. The Bakersfield data set of 10 minute average solar insolation[3] was then used in the computer model along with

[3] Insolation: The rate of delivery of solar radiation per unit of horizontal surface.

power curves from actual solar panels, inverters and a hypothetical wiring arrangement to yield total energy output.

Likely locations for solar installations were discussed with Viejas facilities staff to determine the suitability of various sites. Rooftop, parking lot canopy, and ground based installations were considered in three main areas: the outlet mall, the casino, and residential areas

5.3.3 Cost and Performance Characteristics

Numerous variations in PV cells are available, such as single crystalline silicon, polycrystalline, and thin film panels. Several support structures are available, such as fixed-tilt, one-axis tracking, and two-axis tracking. For evaluation purposes, five single crystalline PV systems are characterized in Table 5-5: two 2.5 kW residential systems and three 100 kW commercial systems

Table 5-5. Solar PV Technology Characteristics.

	Fixed Angle Residential	Two Axis Tracking Residential	Commercial Parking Structure	Commercial Fixed Angle	Commercial One Axis Tracking
Performance					
Typical Duty Cycle	As Available	As Available	As Available	As Available	As Available
Net Plant Capacity, kW	2.5	2.5	100	100	100
Capacity Factor, percent	23%	31%	19%	21%	26%
Economics					
Capital Cost, $/kW	6,800*	8,000*	5,000**	4,700**	5,400**
Fixed O&M, $/kW-yr	45	50	20	20	26
Variable O&M, $/MWh	52	60	23	23	30
Levelized Cost, $/MWh	360	332	220	193	193
Technology Status					
Commercial Status	Commercial				
Installed US Capacity	212 MW				
Viejas Potential	Very Good				

* Includes $2,300/kW California Energy Commission Buy-Down

** Includes $3,000/kW California SELFGEN Incentive

5.3.3.1 Household PV Stationary and Tracking

One way of installing PV Capacity is to install a PV system at a number of the residences on the reservation. The CEC offers an incentive, currently worth $2.80 per installed watt, for this type of installation. An advantage of household PV is that the electricity is generated at the site of the load thus reducing transmission losses. Another advantage of a household level installation is that a battery back up system can be installed as well for an incremental cost which would increase electrical reliability at the residences and provide a degree of energy storage for the system as a whole. The inverters employed for a back up system can provide a degree of voltage regulation by storing or releasing power from the batteries as the local grid requires. Household solar electric systems would engage residential members of the tribe in renewable energy development in a tangible way.

Household PV systems can be mounted on roof tops, on special mounting structures, or on the ground. For this study, two scenarios were analyzed: a fixed slope roof mounted array and a pole mounted two axis tracking array. Both were sized for 2.5 kW AC output and employed a small battery back up system.

Figure 5-16. Pole Mounted Two Axis Tracking PV Array[4]

[4] Source: http://www.solartrax.com/ accessed April 3, 2005

5.3.3.2 Commercial PV Stationary and Tracking

Several scenarios were analyzed for a large scale photovoltaic panel installation. The first is a standard fixed tilt rooftop mounted system. There is no space for solar panels on the casino roof, but the outlet mall has approximately 100,000 square feet of rooftop space available, enough for about 500 kW of PV.

Another option is ground based mounting which is more suited to large scale photovoltaic deployment. Fixed axis or single axis tracking is possible in this configuration. Land required for either scenario is approximately 1 acre for every 200 kW of PV.

A third option is a PV system mounted to provide shade for parking areas. Similar the rooftop system, this option would allow the same area of land to be used for multiple purposes. The panels can be either mounted flat or tilted toward the sun according to aesthetic and performance considerations. The outlet mall has enough parking area for approximately 2 MW of PV. The casino parking area is big enough to theoretically accommodate up to 8 MW assuming good solar exposure over the entire area.

Figure 5-17. Parking Shade PV System. [5]

[5] Source: http://www.nrel.gov/buildings/pv/c_faq.html accessed May 17, 2005

5.4 Bio-Fuels

5.4.1 Biodiesel

Biodiesel is a non-toxic, biodegradable, and renewable fuel that can be used in diesel engines with little or no modification. Biodiesel can be produced from oils such as animal fat, vegetable oil, and waste greases. Biodiesel is produced by breaking a triglyceride (fat) into three ester molecules (which are chain molecules chemically similar to diesel fuel) and a glycerin molecule. Sodium methoxide is added to the oil breaking the triglyceride and bonding methanol to the esters. The mixture to settles into two simpler constituents: glycerin and methyl-ester. The methyl-ester is collected, washed and filtered to yield biodiesel. The glycerin has several commercial uses, the most common of which is the manufacture of soap.

The facilities where biodiesel is produced are relatively simple and easily scaled to meet local needs. Two types of biodiesel production facilities are in operation today: batch plants and continuous flow plants. Batch plants tend to be much smaller than continuous flow plants and produce discrete quantities of biodiesel per batch. Continuous flow plants are usually much larger, run continuously, and are capable of implementing more efficient processes than those used in batch operations. Compared to ethanol, production of biodiesel is still in its infancy. There are very few large scale continuous flow biodiesel plants in operation in the United States at this time.

5.4.1.1 Applications

Biodiesel can directly displace diesel fuel in many applications. Biodiesel requires some special handling and storage procedures, and is limited to use during warm or temperate seasons/climates due to its viscous nature at low temperatures. No engine modifications are required for most static internal combustion (IC) engine applications. While there has been little study of biodiesel’s performance in gas turbine engines, there has been extensive research and testing of the fuel’s performance in traditional four-stroke IC engines. As such, biodiesel is already used in a variety of operations throughout the United States.

Biodiesel’s greatest market potential lies within the transportation sector. However, diesel is generally the fuel of choice for most IC engine power production applications. As such, there is substantial potential for biodiesel to replace diesel fuel in the energy sector. A variety of stationary engine products are available for a range of power generation market applications and duty cycles including standby and emergency power, peaking service, intermediate and base load power, and combined heat and power.

Reciprocating engines are available for power generation applications in sizes ranging from a few kilowatts to over 5 MW.

Diesel engines have historically been the most popular type of reciprocating engine for both small and large power generation applications. However, in the United States and other industrialized nations, diesel engines are increasingly restricted to emergency standby or limited duty-cycle service because of air emission concerns. While biodiesel does improve the emissions of a diesel engine, the improvements are not as significant as the emissions reduction provided by natural gas powered engines.

5.4.1.2 Resource Availability

The most basic feedstock for biodiesel is vegetable oil. The oil can be derived from a variety of sources including: soybeans, cotton, palm, rapeseed, sunflower seeds, and restaurant waste greases. These feedstocks are generally categorized as virgin (fats and oils that have not been previously used) and recycled (fats, oils, and greases that have been previously used). While recycled feedstocks tend to have lower costs, they are limited by their availability and a variety of socioeconomic factors that may not be completely controllable.

In the United States, soybean and corn oil are the two leading vegetable feedstock for biodiesel production. These two feedstocks are readily available throughout most of the country and can be grown in the large quantities necessary to meet large scale biodiesel production demands. The supply of recycled fats and oils is largely determined by the demand from the animal feed industry. While biodiesel demand has been known to have moderate impacts on corn and soybean production, it is unlikely that increases in the demand for biofuels will significantly impact the supply of animal fats or recycled greases.[6]

5.4.1.3 Cost and Performance Characteristics

Currently the production cost of biodiesel can range from about $1.50 to $4.00 per gallon, depending on the feedstock and production method. Biodiesel can be more cost effective when produced from low-cost oils (restaurant waste, frying oils, and animal fats), compared to commodity crops. In January 2005, Imperial Western, a local producer of biodiesel from waste vegetable oil, provided a price of $2.50 a gallon by tanker truck delivered to Viejas.

Integration of biodiesel into the transportation sector has been limited due to the fact that nearly every major diesel engine manufacturer has imposed blend limits on

[6]Agricultural Marketing Research Center, "Biodiesel as a Value-added Opportunity," available at http://www.agmrc.org/energy/info/biodieselopportunity.pdf, accessed 3 August 2004.

biodiesel for warranted operations. Typically, the fuel composition may be restricted to a maximum of 5 percent biodiesel (B5) or 20 percent biodiesel (B20). See attached Caterpillar bio-fuel spec sheet for an example of one manufacturer's fueling recommendations. Recently, some manufacturers have raised their limits to 100 percent biodiesel (B100). Some users have elected to run their engines on B100 and other high percentage blends, conceding the manufacturer's warranty coverage; however, this is a risk that few operators are willing to take.

Gasoline and diesel fuel, and their biofuel counterparts ethanol and biodiesel, are quality controlled based on ASTM specifications. The recent establishment of the ASTM biodiesel specification was a major advance for manufacturers who now have an industry-accepted standard for quality. This new standard will likely lend itself to an increase in large-scale biodiesel production, as well as a greater acceptance of the biofuel by diesel engine manufacturers.

While biodiesel can be used in any standard diesel engine with little to no modification to the engine, due to its different properties, such as a higher cetane number, lower volatility, and lower energy content, biodiesel may cause some changes in the engine performance and emissions. These different properties can affect the injection timing and the diesel combustion process causing lower power output. In contrast, biodiesel has a higher concentration of oxygen (by weight) which lends itself to more complete combustion, and biodiesel's higher cetane number provides smoother combustion and less engine noise.

5.4.2 Waste Vegetable Oil

Research on vegetable oil fuel has shifted to biodiesel in recent years so there is very little literature on the use of straight vegetable oil (SVO) from the past 20 years (although interest was active before that time). It seems that the major problems were associated with the high viscosity of the fuel resulting in a course spray and un-burnt oil which would polymerize on cylinder walls and clog injectors. There is little in the literature to counter the assertion by modern advocates that pre-heating vegetable oil lowers the viscosity sufficiently for complete combustion.

There are currently many individuals in the United States who run their cars on SVO, but it is not without risk. Much of this risk is associated with a do-it-yourself approach. One of the larger companies performing SVO engine conversions interviewed for this study is optimistic about converting a large generator. The largest engines they have converted to date are semi trucks. The vendor was willing to perform a conversion on a generator but not willing to warrant success. The vendor offered to monitor the generator closely to identify early signs of degradation. If using straight vegetable oil is considered desirable, Black & Veatch recommends converting the most expendable of the several generators at Viejas as a trial and convert others if successful. The conversion to SVO would likely violate the engine warranty. However, if the conversion were performed on an older engine the warranty would likely no longer be in effect.

Wartsila does sell generators rated for use with SVO. These generators are originally designed to run on crude oil or one of the more viscous fuel oils (4,5,6). Two generators have been installed in Italy specifically for use with SVO. Wartsila staff noted that the acidity of the oil was the largest concern; so if waste vegetable oil is used some pre-treatment beyond filtering may be necessary. See the attached Wartsila generator Biofuel spec. in Appendix A. Generators from other manufacturers designed for viscous oils may also be able to run on SVO.

Yellow Grease is a commodity product sold for animal feed, cosmetics, and other uses and is essentially minimally processed waste vegetable oil. In California it typically can be obtained for about $1 a gallon, additional processing would be needed to produce fuel quality oil.

5.4.3 Biogas

Anaerobic digestion is the naturally occurring process in which bacteria decompose organic materials in the absence of oxygen. The byproduct gas has 50 to 80 percent methane content. The most common applications of anaerobic digestion use industrial wastewater, animal manure, or human sewage. According to the European Network of Energy Agencies' ATLAS Project, the world wide deployment of anaerobic digestion in 1995 was approximately 6,300 MW for agricultural and municipal wastes. This is estimated to increase to 20,130 MW in 2010 with the majority of that growth in municipal wastewater digestion.

5.4.3.1 Applications

Anaerobic digestion is commonly used in municipal wastewater treatment as a first stage treatment process for sewage sludge. Digesters are designed to convert the organic material or sewage sludge into safe and stable biosolids and methane gas. The use of anaerobic digestion technologies in wastewater treatment applications is increasing because it results in a smaller quantity of biosolids residue compared to aerobic technologies.

In agricultural applications, anaerobic digesters can be installed anywhere there is a clean, continuous source of manure. It is highly desirable that the animal manure be concentrated, which is common at dairy and hog farms. (Poultry litter is dryer and more suitable for direct combustion.) Dairy farms use different types of digesters depending upon the type of manure handling system in place at the farm and the land area available for the digester. A 600 to 700 head dairy farm generally produces sufficient manure to generate about 85 kW. Hog farms typically use simple lagoon digesters because of the wetter manure and generate approximately 50 kW for every 500 swine.

Figure 5-18. 500 m^3 Digester Treating Manure from a 10,000 Pig Farm in China.[7]

In addition to wastewater and agricultural residues, Los Angeles Department of Water and Power has announced a new agreement to purchase power from a 40 MW anaerobic digestion facility that will process 3,000 tons per day of municipal green waste (such as landscape trimmings and food waste). The facility is scheduled to be on-line by 2009. This facility would be the largest of its kind in the world. Other high-solids digestion systems are installed world wide. These are primarily in Europe and Japan and use municipal solid waste and green waste as feedstocks.

Biogas produced by anaerobic digestion can be used for power generation, direct heat applications, and/or absorption chilling. Reciprocating engines are by far the most common power conversion device, although trials with micro turbines and fuel cells are underway. Agricultural digesters frequently satisfy the power demands for the farm on which they are installed, but do not provide significant exports to the grid. Municipal sewage sludge digesters generally produce enough gas to satisfy about half the wastewater treatment plant electrical load. Power production is typically a secondary

[7] Image source: Purdue University, http://pasture.ecn.purdue.edu/~jiqin/PhotoDigester/PhotosDigesters.html.

consideration in digestion projects. Increasingly stringent agricultural manure and sewage sludge management regulations are the primary drivers.

5.4.3.2 Resource Availability

The Viejas Wastewater treatment facility does not currently use an anaerobic digestion stage and the volume of waste flow is likely not sufficient to compel the addition of such a stage. It is possible that off site green waste or manure could be used in a biogas facility but due to Viejas' remote location transportation cost is likely to be an issue.

5.4.3.3 Cost and Performance Characteristics

Table 5-6 provides typical characteristics of farm-scale dairy manure anaerobic digestion systems utilizing reciprocating engine technology.

Table 5-6. Anaerobic Digestion Technology Characteristics.

Performance	
Typical Duty Cycle	Baseload
Net Plant Capacity, MW	0.085
Capacity Factor, percent	70-90
Economics	
Capital Cost, $/kW	2,300-3,800
Variable O&M, $/MWh	15
Levelized Cost, $/MWh	80-120
Technology Status	
Commercial Status	Commercial
Installed Worldwide Capacity, MW_{th}	6,300
Viejas Potential	Fair

* Fuel cost of $0/MBtu assumed.

5.5 Cogeneration

Cogeneration is the combined generation of electricity and heat. A given amount of fuel can provide twice the utility it would otherwise by both generating electricity and using the waste heat from that generation. Though not strictly 'renewable', cogeneration does offer an opportunity to reduce fossil fuel use through more effective use of fossil fuels. Furthermore most cogeneration technologies are suitable for operation with one or more renewable fuels, such as biodiesel, SVO, and biogas. Cogeneration requires heat and electric loads that are well matched. Usually one or the other is limiting. For Viejas one of two strategies can be employed. The first is installing cogeneration devices to meet the heat load of the reservation with electricity as a byproduct. In this scenario the value of each MWh generated is \$30 to \$50 higher due to the value of the heat provided (natural gas not burned). The second strategy would be to install thermal generation sized to meet electrical needs and finding ways of utilizing the waste heat. Various companies have integrated thermal generation sources and absorption chillers to provide electricity, cooling, and heating from a single package. In this way fuel use efficiency rises from approximately 33 percent for simply generating electricity to 70 or 80 percent by making use of the waste heat. Below are listed four thermal generation technologies and three potential uses for waste heat.

5.5.1 Reciprocating Engines

Reciprocating engines are well proven prime movers for electric generation, industrial processes, and many other applications. Reciprocating engines operate according to either an Otto or Diesel thermodynamic cycle, very much like a personal automobile. These cycles use similar mechanics to produce work, but differ in the way that they combust fuel.

5.5.1.1 Operating Principles

Reciprocating engines contain multiple pistons that are individually attached by connecting rods to a single crankshaft. The other ends of the pistons seal combustion chambers where fuel is burned. A mixture of fuel and air is injected into the combustion chamber and an explosion is caused. The explosion provides energy to force the pistons down and this linear motion is translated into angular rotation of the crankshaft by the connecting rods. The combustion chambers are vented and the piston pushes the exhaust gases out completing the full rotation of the crankshaft. The process is repeated and work is performed.

Figure 5-19. Engine Generator (Source: Caterpillar Corporation).

5.5.1.2 Applications

Reciprocating engine generator sets are commonly used for self-generation of power either for emergency backup or peak shaving. However, there is also a well established market for installation of generator sets as the primary power source for small power systems and isolated facilities that are located away from the transmission grid.

When used for power generation, medium speed engines (less than 1,000 rpm), are typically used since they are more efficient and have lower O&M costs than smaller higher speed machines. Efficiency rates for reciprocating engines are relatively constant from 100 to 50 percent load, they have excellent load following characteristics, and they can maintain guaranteed emission rates down to approximately 25 percent load, thus providing superior part-load performance. Typical startup times for larger reciprocating engines are on the order of 15 minutes. However, some engines can be configured to start up and be completely operational within 10 seconds for use as emergency backup power.

Fuel Flexibility

Spark ignition and compression ignition engine generator sets can burn a wide variety of fuels. This list includes diesel, natural gas, biogas, landfill gas, ethanol, propane, naphtha, strait vegetable oil, and biodiesel. Because they have such flexibility, engine generators are well-suited for use as conventional or renewable power generation.

Performance and Cost Characteristics

Table 5-7 provides estimates of performance and costs for a reciprocating engine power station.

Table 5-7. Reciprocating Engine Technology Characteristics

Engine Type	**Compression (Biodiesel)**	**Compression (Vegetable Oil)**
Commercial Status	Commercial	Commercial
Performance		
Net Plant Capacity, kW	1-10,000	1-10,000
Net Plant Heat Rate, Btu/kWh	8,500	8,500
Capacity Factor, percent	30-70	30-70
Economics		
Capital Cost, $/kW	600	800
Variable O&M, $/MWh	15-25	15-25
Levelized Cost, $/MWh *	200	130
* Biodiesel $15/MBtu, Vegetable Oil $8/MBtu		

5.5.2 Combustion Turbine

The first successful combustion turbine was completed in 1903. Over the next forty years, rapid advances were made to improve the technology to make it a viable means of aircraft propulsion. As the technology matured, combustion turbines were adapted to land-based energy generation uses. With the deregulation of the power industry in the 1990s, combustion turbines became the generator of choice for a vast majority of new power projects. Combustion turbines currently have lower capital costs, shorter construction durations and lower operation and maintenance costs than any other large central plant available on the market. The primary constraint to their continued prominence is the current high price of natural gas and diesel fuel.

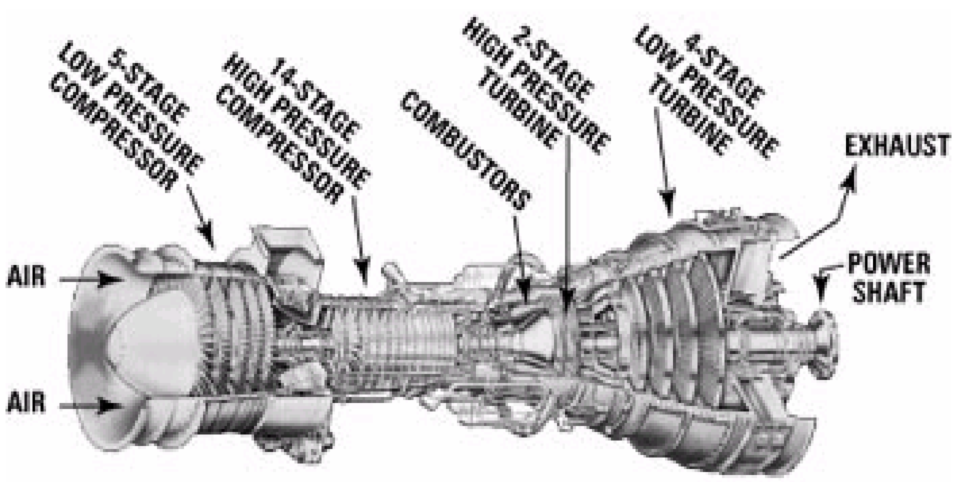

Figure 5-20. Combustion Turbine Section (Source: Langston).

5.5.2.1 Operating Principles

Power is generated when the combustion turbine compresses ambient air to approximately 12 to 16 atmospheres, heats the pressurized air to 2,000°F or more by burning oil, natural gas or renewable fuels, and then expands the hot gas through a turbine. The turbine then drives both the air compressor and an electric generator. A typical combustion turbine would convert 30 to 35 percent of the fuel energy to electric power, with a substantial portion of the fuel energy exhausted in the form of hot (>900°F) gases exiting the turbine. When the combustion turbine is used to generate power and no energy is captured from the hot exhaust gasses, the power cycle is referred to as a "simple cycle" power plant.

Applications

Simple cycle combustion turbines are the power generation technology of choice for peaking service in the current domestic power industry. Simple cycle technology provides many of the same positive attributes as reciprocating engines, including rapid startup and modularity for ease of maintenance. In addition, combustion turbines have several advantages over reciprocating engines, including lower emissions and lower capital cost.

Fuel Flexibility

Like the reciprocating engine, simple cycle turbines are a conventional technology that can be adapted to burn renewable fuels. Simple cycle turbines can burn natural gas, diesel, propane, biogas and some bio-derivative fuels such as biodiesel, ethanol and bio-oil. It should be noted, however, that manufacturers of combustion turbines do not necessarily encourage such fuel flexibility, and burning of alternative fuels may void warranty coverage.

Performance and Cost Characteristics

Generic performance and cost estimates for small simple cycle combustion turbines are listed in Table 5-8. For reference, the price of fuel is assumed to be $9/MBtu equivalent to the current price of natural gas at Viejas.

Table 5-8. Simple Cycle Combustion Turbine Technology Characteristics.	
Commercial Status	Commercial
Performance	
Net Plant Capacity, kW	300-10,000
Net Plant Heat Rate, Btu/kWh,	11,000
Capacity Factor, percent	30-70
Economics	
Capital Cost, $/kW	1500
Variable O&M, $/MWh	15-25
Levelized Cost, $8.8/MBtu Fuel, $/MWh	150

5.5.3 Microturbines

The microturbine is essentially a small version of the combustion turbine. It is typically offered in the size range of 30 to 60 kW. These turbines were initially developed in the 1960's by Allison Engine Co. for ground transportation. The first major field trial of this technology was in 1971 with the installation of turbines in six Greyhound buses. By 1978, the busses had traveled more than a million miles and the turbine engine was viewed by Greyhound management as a technical breakthrough. Since this initial application, microturbines have been used in many applications including small scale electric and heat generation in industry, waste recovery, and continued use in electric vehicles.

Operating Principles

Microturbines operate on a similar principle to that of larger combustion turbines. Atmospheric air is compressed and heated with the combustion of fuel, then expanded across turbine blades which in turn operate a generator to produce power. The turbine blades operate at very high speed in these units, up to 100,000 rpm, versus the slower speeds observed in large combustion turbines. Another key difference between the large combustion turbines and the microturbines is that the compressor, turbine, generator, and electric conditioning equipment are all contained in a single unit about the size of a refrigerator, versus a unit about the size of a rail car. The thermal efficiency of these smaller units is currently in the range of 20 to 30 percent, depending on manufacturer, ambient conditions, and the need for fuel compression; however, efforts are underway to increase the thermal efficiency of these units to around 40 percent.

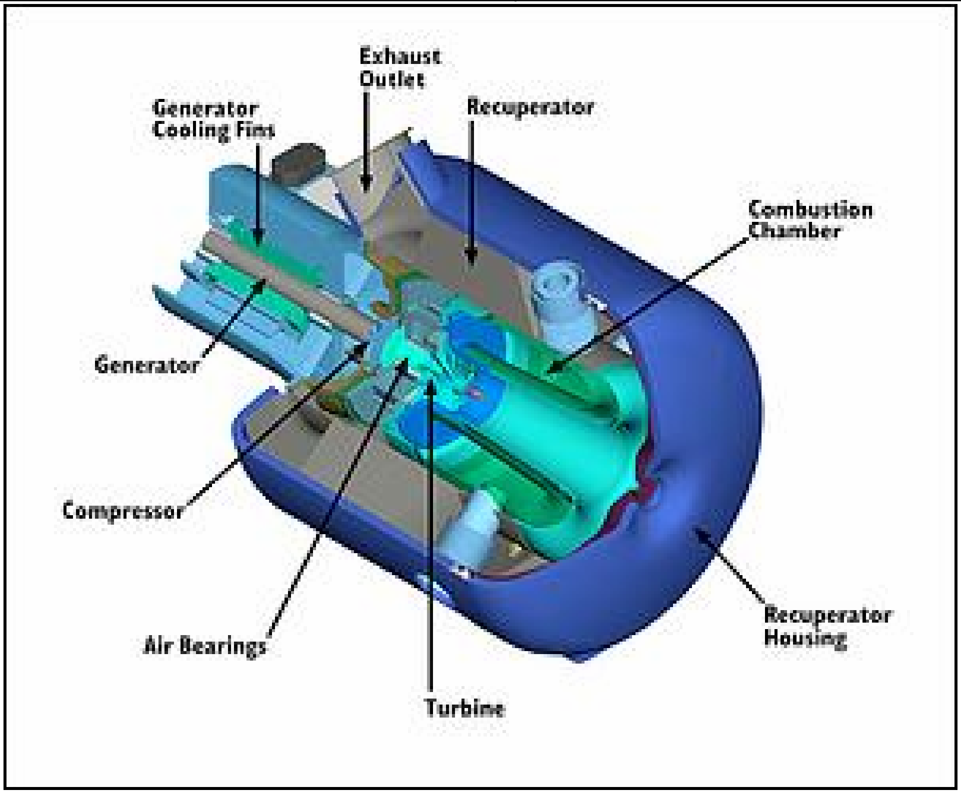

Figure 5-21. Microturbine Cutaway View (Source: Capstone Turbine Corporation.)

Applications

Potential applications for microturbines are very broad, given the fuel flexibility, size, and reliability of the technology. The units have been used in electric vehicles, distributed generation, and resource recovery applications. These systems have been used in many remote power applications around the world to bring reliable generation outside of the central grid system. In addition, these units are currently being used in several landfill sites to generate electricity with landfill gas fuel to power the facilities on the site. For example, the Los Angeles Department of Water and Power recently installed an array of 50 microturbine generators at the Lopez Canyon landfill. The project has a net output of 1,300 kW.

Fuel Flexibility

Microturbines offer a wide range of fuel flexibility, with fuels suitable for combustion including: natural gas, ethanol, propane, biogas, and other renewable fuels. The minimum requirement for fuel heat content is around 350 Btu/standard cubic foot, depending upon microturbine manufacturer.

Performance and Cost Characteristics

Microturbine costs are often discussed as being about $1,000 per kilowatt. However, this is typically just the bare engine cost. Auxiliary equipment, engineering, and construction costs can be significant. Table 5-9 provides performance and cost characteristics for typical microturbine installations. For reference, the price of fuel is assumed to be $9/MBtu equivalent to the current price of natural gas at Viejas.

Table 5-9. Microturbine Technology Characteristics.

Commercial Status	Early Commercial
Performance	
Net Capacity per Unit, kW	30-250
Net Plant Heat Rate, Btu/kWh	12,200 – 15,000
Capacity Factor, percent	30-70
Economics	
Capital Cost, $/kW*	2,200
Variable O&M, $/MWh	10-20
Levelized Cost, $8.8/MBtu Fuel, $/MWh	145

* Average of completed California SELFGEN projects

5.5.4 Fuel Cell

Fuel cell technology has been developed by government agencies and private corporations. Fuel cells are an important part of space exploration and are receiving considerable attention as an alternative power source for automobiles. In addition to these two applications, fuel cells continue to be considered for power generation for permanent power and intermittent power demands. Figure 5-22 shows an example of a fuel cell in a distributed generation application.

Figure 5-22. 200 kW Fuel Cell (Source: UTC Fuel Cells).

Operating Principles

Fuel cells convert hydrogen-rich fuel sources directly to electricity through an electrochemical reaction. Fuel cell power systems have the promise of high efficiencies because they are not limited by the Carnot efficiency that limits thermal power systems. Fuel cells can sustain high efficiency operation even under part load. The construction of fuel cells is inherently modular, making it easy to size plants according to power requirements.

There are four major fuel cell types under development: phosphoric acid, molten carbonate, solid oxide, and proton exchange membrane. The most developed fuel cell technology for stationary power is the phosphoric acid fuel cell (PAFC). PAFC plants range from around 200 kW to 11 MW in size and have efficiencies on the order of 40 percent. PAFC cogeneration facilities can attain efficiencies approaching 88 percent when the thermal energy from the fuel cell is utilized for low grade energy recovery. The potential development of solid oxide fuel cell/gas turbine combined cycles could reach electrical conversion efficiencies of 60 to 70 percent.

Applications

Most fuel cell installations are less than 1 MW. Commercial stationary fuel cell plants are typically fueled by natural gas, which is converted to hydrogen gas in a reformer. However, if available, hydrogen gas can be used directly. Other sources of fuel for the reformer under investigation include methanol, biogas, ethanol, and other hydrocarbons.

In addition to the potential for high efficiency, the environmental benefits of fuel cells remain one of the primary reasons for their development. High capital cost, fuel cell stack life, and reliability are the primary disadvantages of fuel cell systems and are the focus of intense research and development. The cost is expected to drop significantly in the future as development efforts continue, partially spurred by interest by the transportation sector.

Performance and Cost Characteristics

The performance and costs of a typical fuel cell plant are shown in Table 5-10. A significant cost is the need to replace the fuel cell stack every 3 to 5 years due to degradation. The stack alone can represent up to 40 percent of the initial capital cost. Most fuel cell technologies are still developmental and power produced by commercial models is not competitive with other resources. For reference, the price of fuel is assumed to be $9/MBtu equivalent to the current price of natural gas at Viejas. In our model we also modeled using wind from a small wind farm to produce hydrogen. The opportunity cost of the fuel came to $22/MBtu, but the capital cost of the equipment is subsidized by $4,500/kW in this scenario. Coincidentally the cost of energy in the two scenarios is approximately equivalent.

Table 5-10. Fuel Cell Technology Characteristics

Commercial Status	Development / Early Commercial
Performance	
Net Capacity per Unit, kW	100-1000
Net Plant Heat Rate, Btu/kWh	7,000-9,500
Capacity Factor, percent	30-70
Economics	
Capital Cost, $/kW*	7,700
Fixed O&M, $/kW-yr**	600
Variable O&M, $/MWh	10
Levelized Cost, $8.8/MBtu Fuel, $/MWh	300
Levelized Cost, $22/MBtu Fuel, and $4.50/W Subsidy, $/MWh	300

* Average of completed California SELFGEN projects
** Includes costs for cell stack replacement every four years.

5.5.5 Commercial Hot water

Viejas currently has demand for approximately two million BTU/hour of hot water at the Casino's two main boilers. This translates into approximately 400 kW of generation supplying waste heat to provide the hot water. An engine generator, fuel cell, or micro turbines can be installed to meet this need.

5.5.6 Commercial Absorption Cooling

Absorption chillers differ from the more prevalent compression chillers in that the cooling effect is driven by heat energy, rather than mechanical energy. The simplest absorption machines are propane recreational vehicle refrigerators which operate without electricity. An absorption chiller is larger and more complicated, but the basic principle is the same. Lithium bromide-water (LiBr/H2O) systems are one of the more common systems, with lithium bromide as the absorbent and water as the refrigerant.

In an LiBr/H2O absorption chiller an evaporator allows water under vacuum to evaporate absorbing heat. The water is then absorbed into a solution by the hydrophilic absorbent lithium bromide. The combined fluids then go to a generator, which is heated by the heat source (combustion gas, steam, hot oil), boiling the water back out of the absorbent as a gas. The water then goes to a condenser to be cooled back down to a liquid, while the absorbent is pumped back to the absorber. The cooled water is released through an expansion valve into the evaporator, and the cycle repeats.

There is a large capital cost of switching from compressor based chillers to absorption chillers, on the other hand, a 'free' source of heat will likely justify the capital investment. If Viejas decides to operate a megawatt scale thermal generation source switching to absorption chillers at the casino should be investigated more thoroughly. For any new cooling loads looking at absorption chillers with associated thermal generation is recommended.

The current cooling load on the casino is sufficient to utilize the waste heat from a one to three MW combustion turbine or other thermal generation source.

5.5.7 Sludge Drying

Sludge being hauled from Viejas is currently estimated to be only one percent dry solids. The other 99 percent is water. Hauling charges are not insignificant. By using waste heat from thermal generation the sludge can be further reduced in an evaporative process. The waste heat from approximately 200 kW of thermal generation would be sufficient to dry the sludge completely.

A centrifuge drying process will likely bring the dry solids to approximately 20 percent solids and only 150 gallons per day of total sludge. Waste heat from only ten kilowatts of thermal generation would be required to dry this sludge. This small of a system is likely not worth the additional maintenance of a separate small generator but if waste heat from another source is available opportunistic use could be made. Another solution would be to employ an engine driven centrifuge and use the waste heat from the drive engine to dry the sludge. Technical and odor issues may make this use of waste heat to evaporate sludge infeasible.

6.0 Energy Storage and Load Management

6.1 Energy Storage

Energy storage technologies convert and store electricity to help alleviate disparities between electricity supply and demand. Energy storage systems increase the value of power by allowing better utilization of off-peak baseload generation and through mitigation of instantaneous power fluctuations. This section presents and discusses the generating descriptions, performance, and cost characteristics of pumped hydro energy storage, battery energy storage, compressed air energy storage, and hydrogen energy storage systems.

6.1.1 Pumped Hydro

Pumped hydro energy storage is the oldest and most prevalent of the central station energy storage options. Approximately 22 GW of pumped storage generation is installed in the US[8]. A pumped storage hydroelectric facility requires a reservoir/dam system similar to a conventional hydroelectric facility. Excess energy from the grid (available at low cost) is used to pump water from a lower reservoir to an upper reservoir above a dam. When energy is required during high cost, peak electrical demand periods, the potential energy of the water in the upper reservoir is converted to electricity as the stored water flows through a turbine to the lower reservoir.

Capital cost and lead time are the primary considerations in implementing this storage technology. Capital costs are typically high on a per kW basis and a 4 or 5 year construction period for larger pumped storage facility may be expected. Furthermore, it is becoming much more difficult to gain environmental approvals for damming river systems, making the permitting/environmental risk of pumped storage facilities a significant consideration. Geographic and geologic conditions largely preclude many areas from consideration of this technology. Table 6-1 presents typical performance and cost estimates for pumped hydro energy storage.

[8] US Department of Energy, EPRI, "Renewable Energy Technology Characterizations," December 1997.

Table 6-1
Pumped Hydro Energy Storage - Performance and Costs

Commercial Status	Commercial
Construction Period (months)	12-60
Performance	
Plant Capacity (MW)	1-1,500+
Capacity Factor (percent)	10-40
Economics (2004$)	
Total Project Cost ($/kW)	1,550-3,600
Fixed O&M ($/kW-yr)	5-13
Variable O&M ($/MWh)	2.5-4.5
Levelized Cost ($/MWh)	140*
* Using wind energy valued at $60/MWh for pumping	

6.1.2 Batteries

A battery energy storage system consists of the battery, dc switchgear, dc/ac converter/charger, transformer, ac switchgear, and a building to house the components. During peak power demand periods, the battery system can discharge power to the utility system for about 4 to 5 hours. The batteries are then recharged during nonpeak hours. In addition to the high initial cost, a battery system will require replacement every 4 to 10 years, depending on the duty cycle.

Currently, the only commercially available utility size battery systems are lead-acid systems. Research to develop better performing and lower cost batteries such as sodium-sulfur and zinc-bromine batteries is currently underway. The overall efficiency of battery systems averages 72 percent from charge to discharge. The cost and performance of a 5 MW (15 MWh) system is provided in Table 6-2.

Table 6-2
Lead-Acid Battery Energy Storage - Performance and Costs

Commercial Status	Commercial
Construction Period (months)	12-18
Performance	
Plant Capacity (MW)	5
Energy Capacity (MWh)	15
Capacity Factor (percent)	10-15
Economics (2004$)	
Total Project Cost ($/kW)	850-1,700
Fixed O&M ($/kW-yr)	15
Variable O&M ($/MWh)	80
Levelized Cost ($/MWh)	250 *
* Assumed wind energy at $60/MWh to charge batteries	

6.1.3 Compressed Air Energy Storage

Compressed air energy storage (CAES) is a technique used to supply electrical power to meet peak loads within an electric utility system. This method uses the power surplus from baseload coal and nuclear plants during off-peak periods or excess wind energy to compress and store air in an underground formation. The compressed air is later heated (with a fuel) and expanded through a gas turbine expander to produce electrical power during peak power demand. A simple compressed air storage plant consists of an air compressor, turbine, motor/generator unit, and a storage vessel (typically underground). Exhaust gas heat recuperation may be added to increase cycle efficiency.

The theoretical basis associated with the thermodynamic cycle for a compressed air storage facility is that of a simple gas turbine system. Typically, gas turbines will consume 50 to 60 percent of their net power output to operate the air compressor. In a compressed air storage generating plant, the air compressor and the turbine are not connected and the total power generated from the gas turbine is supplied to the electrical grid. By using off-peak energy to compress the air, the need for expensive natural gas or imported oil is reduced by as much as two-thirds compared with conventional gas turbines.[9] This results in a very attractive heat rate for CAES plants, ranging from 4,000 to 5,000 Btu/kWh. Because fuel (typically natural gas) is supplied to the system during

[9] Nakhamkin, M., Anderson, L., Swenson, E., "AEC 110 MW CAES Plant: Status of Project," Journal of Engineering for Gas Turbines and Power, October 1992, Vol. 114.

the energy generation mode, CAES plants actually provide more electrical power to the grid than was used during the cavern charging mode.

The location of a CAES plant must be suitable for cavern construction or for the reuse of an existing cavern. However, suitable geology is widespread throughout the United States with over 75 percent of the land area containing appropriate geological formations. There are three types of formations that can be used to store compressed gases: solution mined reservoirs in salt, conventionally mined reservoirs in salt or hard rock, and naturally occurring porous media reservoirs (aquifers).

The basic components of a CAES plant are proven technologies and CAES units have a reputation for achieving good availability. The first commercial scale CAES plant in the world is a 290 MW plant in Huntorf, Germany. This plant has been operated since 1978, providing 2 hours of generation with 8 hours of charging. In 1991, a 110 MW CAES facility in McIntosh, Alabama, began operation. This plant remains the only US CAES installation, although several new plants have been recently announced. Table 6-3 shows the performance and cost characteristics of a CAES system.

Compressed air energy storage is likely not suitable for smaller gas turbines such as would be suitable for Viejas. Considering the small differential between peak and off peak power, and the large scale of the technology, CAES does not seem to be a good match for Viejas.

Table 6-3
Compressed Air Energy Storage - Performance and Costs

Commercial Status	Commercial
Construction Period (months)	26-29
Performance	
Plant Capacity (MW)	100-500
Net Plant Heat Rate (Btu/kWh)	4,000-5,000
Capacity Factor (percent)	10-40
Economics (2004$)	
Total Project Cost ($/kW)	480-730
Fixed O&M ($/kW-yr)	5.30-16.0
Variable O&M ($/MWh)	3.20-6.35
Levelized Cost ($/MWh)	130

* Assumed wind energy at $60/MWh to compress air

6.1.4 Hydrogen

A hydrogen-based system is considered as an energy storage system only if the production of hydrogen is part of the overall system. If the hydrogen is supplied as a consumable, then the system is considered as a generator. Typical applications include peak shaving and transmission deferral. A hydrogen-based energy system for distributed generation consists of an electrolyzer, a hydrogen storage pressurized tank, and a fuel cell or a combustion engine. The electrolyzer generates hydrogen using water, as the raw material, through the process of electrolysis. The hydrogen produced is stored in a tank under pressure. Either a fuel cell or a combustion engine can then utilize the hydrogen to generate electricity. The hydrogen energy storage system can generate electricity for a duration of 0.5 to 4 hours and stored energy ranges between 50 and 8,000 kWh. [10]

Electrolyzers are commercially available at various sizes and can generate hydrogen up to a pressure of about 290 psi[10]. An electrolyzer requires water to generate hydrogen via electrolysis. Cooling water is also required in the process. For small remote application, such as for a telecom system, a water storage tank is required on site. For a larger application such as for a residential area, feed water can be extracted from the existing water pipeline. The electorlyzer has a typical efficiency of about 70 percent (lower heating value)[11]. The hydrogen gas produced by the electrolyzer is stored as a pressurized gas at 2,500-3,000 psi using compressors or as a metal hydride. For a small application, compressed gas storage is more cost effective than metal hydride.[11] A suitable fuel cell technology for this type of application is the proton exchange membrane (PEM) fuel cell which operates on hydrogen and air at ambient conditions[10]. The efficiency of PEM fuel cell is about 40-50 percent (lower heating value and based on pure hydrogen fuel)[11]. Alternatively, a combustion engine can be used to burn the hydrogen to generate power with an efficiency of about 44 percent[10].

A representative performance and cost characteristics of a hydrogen fuel cell are summarized in Table 6-4 based on fuel cell as the power generation technology.

[10] Schoenung, S.M. and Hassenzahl, W.V. "Long-vs. Short-Term Energy Storage Technologies Analysis, Life-Cycle Cost Study, A Study for the DOE Energy Storage Systems Program," Sandia Report (SAND2003-2783), printed August 2003.
[11] Cotrell, J. and Pratt, W. "Modeling the Feasibility of Using Fuel Cells and Hydrogen Internal Combustion Engines in Remote Renewable Energy Systems," NREL (NREL/TP-500-34648), September 2003.

Table 6-4 Hydrogen Energy Storage - Performance and Costs	
Commercial Status	Commercial
Construction Period (months)	3-6
Performance	
Plant Capacity (MW)	0.1-2
Net Plant Heat Rate (Btu/kWh)	7,500-8,000
Capacity Factor (percent)	5-70
Economics (2004$)	
Total Project Cost ($/kW)	5,000-5,500
Fixed O&M ($/kW-yr)	350-400
Levelized Cost ($/MWh)	340
* Assumed wind energy at $60/MWh to electrolyze hydrogen and 40% efficient fuel cell	

6.2 Load Management

6.2.1 Dispatchable Loads

Some electrical loads can provide the same utility to the user independent of when they are dispatched, within a certain time frame. Using this attribute to manage power consumption is called load shifting. Load shifting can be an effective way to match load profile with renewable generation. Loads which may be delayed in time are held off until sufficient generation is present. Three major dispatchable loads have been identified at Viejas, the waste water treatment plant, well pumps, and the central chiller plant.

The waste water treatment plant draws approximately 250 kW with a load factor of 50 percent and storage for more than a day. Thus the waste water treatment plant can be operated at times of the day when energy is less costly or generated energy is in abundance.

The well pumps have a draw of approximately 150 kW and have load factors of between 33 and 85 percent. Storage in existing tanks is sufficient for between 12 to 36 hours, depending on the season. Thus the well pumps can be operated to avoid power draw during the most critical hours of the day throughout the year.

The central chiller plant can draw up to 1800 kW with a load factor of between 15 and 75 percent depending on the season. A certain amount of dispatchability is inherent in the system. On the level of minutes to an hour the deployment of the chillers can be delayed or anticipatively deployed while keeping the building temperature within specified bounds. A cold water storage tank could be installed and sized to provide storage in the range of hours. Ice could be employed to store cold for longer periods. Adding storage elements to a system adds cost but these are often less expensive than adding a corresponding dispatchable generation source.

Loads may be dispatched to avoid using power during peak energy cost periods, to use power during periods of peak generation, or to balance overall power demand.

6.2.2 Energy Efficiency

One of the best ways to manage load is to simply have the same functions performed with less energy. There is a wide range of opportunity for both business and residential energy users to save energy. Most utilities have programs for educating their rate payers about energy efficient appliances and strategies. San Diego Gas and Electric has several energy efficiency programs and information available on energy efficiency strategies. The SDG&E website for information on residential programs and strategies is http://www.sdge.com/residential/res_energy_efficiency.shtml. The website for business programs and strategies is http://www.sdge.com/business/bus_energy_efficiency.shtml.

One effective way to reduce electrical demand is through the use of an electrical services company. Johnson Controls, Inc. (JCI), one such company, is currently is providing Viejas services on the chiller system. A comprehensive look at loads and generation by qualified professionals could identify significant energy savings and load shifting possibilities. These opportunities may be developed within a performance contract where Viejas pays none of the upfront cost but rather a portion of the energy savings goes to paying off the improvements. One possibility would be to have an energy services company and Black & Veatch work together to identify and implement generation and conservation activities in a complimentary way; with Black & Veatch providing the renewable energy expertise and the energy services company providing the efficiency know-how and performance contract.

6.3 Energy Strategy

If deployed skillfully, load diversion and dispatchable generation can have a greater effect than merely the energy saved, generated, or deferred. By understanding the rules of a billing rate or power purchase agreement, skillful management of energy resources can result in significant savings.

6.3.1 Time of Use

Many billing rates and power purchase agreements use the time of use to determine the value of energy consumed. Typically there will be a peak period and potentially several other periods of the day with different energy charges. This is in contrast to a flat rate in which the same value is placed on electricity around the clock.

Sources of generation, such as solar, have a natural tendency to coincide with afternoon peak periods and thus would be a good match for use with a strong time of use rate. Furthermore Loads may be diverted to off peak times to take advantage of lower rates. Dispatchable generation which may be too expensive to run in a flat rate situation may be cost effective to run during peak periods of the day.

In a net metering arrangement using solar or wind (both are strong producers in the afternoon at Viejas) an extra kilowatt-hour generated during a peak rate time would be more valuable than off peak due to the higher value of energy at peak times.

6.3.2 Demand Charge Reduction

Demand charges, or payments based on the maximum electricity demand during a given period, usually monthly or annually, can be a significant cost. If Viejas or one of the Viejas accounts were to draw twice their average demand for even 15 minutes a month the demand charges for that month will be twice what they would have been if demand had been kept level. Such peaks in usage are quite common. Though they do not represent a large percentage of energy consumed they can represent a large portion of a monthly bill. Some billing rates employ time of use demand charges, which vary by time of day, such that capacity payments during off peak periods may be insignificant while avoiding demand charges during peak periods can be quite advantageous. Certain loads that may be able to be diverted for as little as 15 minutes can have a good effect on demand charges.

A generation source that may otherwise be prohibitive to employ may become very valuable if run for only a few hours per month to eliminate peaks in power consumption. Demand charges are calculated based on the maximum power consumed even if it is only for a short period once in the month; this makes effective automatic monitoring and control imperative to implementing a demand charge reduction program. Proper control eliminates the lone mistake which negates the benefit of all efforts put into demand charge reduction for the period.

6.3.3 Fitting to a Billing Rate

Different billing rates or power purchase agreements will have widely varying energy charges, demand charges, time of use structure, and other components and requirements. Normally it is important to chose the correct billing rate (or negotiate a power purchase agreement) to match load patterns. In the case where one is generating a significant amount of ones own power and has a measure of control of loads it may be advantageous to tailor ones generation to qualify for and take advantage of a given rate. Simulations can be run with Viejas loads and generation sources against different potential billing rates or power purchase agreements to find which Viejas can best take advantage of.

An example of all three of these strategies can be seen at Palmdale Water District's Clear Well pumping station. The pumping station has an average load of approximately 400 kW and a peak load of near 700 kW. The pumping station qualifies for a very favorable pumping and irrigation rate if its maximum load does not exceed 500kW. By strategically deploying some load diversion, a small hydro electric generator, and a natural gas reciprocating engine, maximum loads may be kept down below 500kW and significant savings is realized. Furthermore, once the goal of keeping maximum load below 500 kW has been met, remaining load shifting, hydro, and generator capacity are used to reduce time of use, energy, and capacity charges.

7.0 Electrical Interconnection

As discussed in Section 3.0, Viejas has several energy development options to consider. Each of the three options requires varying levels of electrical interconnection arrangements. A map characterizing each option is located in Appendix B. This section reviews each option and characterizes the interconnection costs of each option. These costs are used to characterize severance scenario costs further evaluated in Section 8.0.

Note that in contrast to the 'Net Metering' planning scenario discussed in Section 3.1 and evaluated in Sections 10 and 13, the following severance scenario evaluates the cost and electrical configuration option Viejas may have available should Viejas choose to form an electric utility. The severance scenarios in Section 7.1 and 7.3 are both sensitivities to the Base Case 'Interconnected Utility' severance scenario evaluated using the financial model in Section 13.2.

7.1 Net Metering on Individual Accounts

Net metering is an arrangement with SDG&E where a renewable generation source on Viejas property feeds forward and backward through the current electrical meter. Viejas is billed only for the net energy consumed over a one year period. California's net metering law allows up to 1MW of renewable generation per meter to be placed on a net metering rate.

One approach to integrating renewable energy into the Viejas energy mix would be to leave the existing structure and relationship with SDG&E in place and net meter renewable generation on the reservation. Projects would be scaled to approximately match the annual energy consumption at the meter to which they were interconnected. On a project by project basis it can be decided which are desirable based on economic and other factors.

For accounts where generation will not exceed minimum load, no net metering agreement is necessary, and any generation type may be employed. This assumes that all interconnection, environmental, and safety standards are met.

7.1.1 Severance Scenario 1 (Net Metering)

In this severance scenario, Viejas will need to negotiate with SDG&E and obtain permission to wheel wholesale power through SDG&E's distribution system. SDG&E tariffs, CPUC regulations, and other regulations may prohibit the wheeling of wholesale power via distribution lines. In the case that wholesale power is permitted to be wheeled via distribution lines, the distribution system within the Reservation would be purchased from SDG&E, and the energy coming into the system would be primary metered at one location. Another cost consideration incorporated in the model is the distribution cost SDG&E will charge for Viejas' wheeling of wholesale power via SDG&E's distribution system. The model assumes a $0.035/kwhr charge for wheeling. Table 7-1 shows the cost components comprising Severance Scenario 1.

Table 7-1. Severance Scenario 1 Cost Breakdown and Estimate

Net Meter Installation	$60,000
Pole Replacement/Additions	$95,000
Service cut-overs and change-outs	$60,000
Admin, Engineering & Labor Costs	$35,000
Total Estimate	**$250,000**

Noteworthy items for this scenario are that Viejas will still be under SDG&E tariffs; and Viejas will be a part of SDG&E's distribution system.

7.2 Tribal Utility Interactive with the Grid

A second option would be formation of a separate utility. The tribal utility would have a wheeling agreement with SDG&E and power purchase agreements with energy suppliers. The tribal utility would likely operate most of the on-reservation generation. This option is assumed to be the 'Base Case' severance scenario in Section 13.0 Economic Analysis.

7.2.1 Severance Scenario 2

Black & Veatch estimated a $600,000/mile cost for the construction of a 69 KV transmission line; this amount was used as an input in the model. From a brief site inspection it is assumed that the majority of the Reservation's load would be served by one substation being fed from the 69 KV transmission line. Additional cost considerations will include engineering and distribution work to reconfigure the SDG&E existing distribution. Table 7-2 shows the components comprising the Interconnected Utility Distribution System Severance Cost.

Table 7-2. Severance Cost Breakdown and Estimates

Building of 69 KV Transmission Line to Reservation	$4,800,000
New Reservation Sub-station Transformer	$175,000
Feeder Connection from Sub-station to Viejas Distribution	$60,000
Pole Replacement/Additions	$95,000
Service cut-overs and change-outs	$60,000
Admin, Engineering, and other Labor Costs	$250,000
Total Estimate	**$5,440,000**

A detailed study on building a 69 KV transmission line to the reservation will need to be conducted to ascertain firm costs and schedules for this endeavor.

7.3 Tribal Utility Independent of the Grid

For the option of forming a utility that is capable of providing all generation needs independent of the outside grid, a connection would likely still be in place. However, an outage or a cost of energy increase on the grid would not necessarily translate into either outage or dramatically increased cost of energy on the reservation.

In this ambitious scenario sufficient generation, storage, and load diverting capability would need to be in place to balance generation and loads on site in absence of the support of the grid. Additional power quality equipment would likely be required. The main advantage of this scenario is self sufficiency, security, and self reliance. Viejas could still interact with the grid, buying and selling power but would not be required to.

7.3.1 Severance Scenario 3 (Dedicated Distribution Line)

In this severance scenario Viejas will build a dedicated distribution line leading from the Alpine Substation to the Reservation. The delivery point to the utility will be at the substation; thus, Viejas will not incur any distribution wheeling charge. Table 7-3 shows the cost components comprising Severance Scenario 3.

Table 7-3. Severance Scenario 3 Cost Breakdown and Estimates

Building of Dedicated Distribution Circuit	$196,000
New Sub-Station Transformer	$160,000
Transmission Connection	$85,000
Pole Replacement/Additions	$110,000
Service cut-overs and change-outs	$85,000
Admin, Engineering and other Labor Costs	$350,000
Total Estimate	**$986,000**

8.0 Distribution System Audit

8.1 Distribution System Overview

Black & Veatch performed an audit of the electric distribution system assets located within Viejas Tribal Government land. This audit included visual inspection of all distribution equipment to determine the condition of the assets, and assess their value.

8.2 Distribution System Condition and Information

Black & Veatch's review of the assets determined that the system is in good condition for its age. The majority of the system was installed between the years 1988 and 1995. Underground distribution lines were not inspected as part of the audit.

At the time of the audit, the system included 140 poles of one-phase distribution line, and 102 three-phase line. A review of Viejas Tribal Government land and a mapping of the distribution system were used to estimate how many miles of overhead line are located on the system.

Black & Veatch estimates eight miles of overhead line on the system. Without access to a detailed map of the system, Black & Veatch is unable to estimate the length of underground distribution lines. The distribution system valuation methodology is detailed below.

8.3 Distribution System Valuation

In general, public utility commissions and courts have recognized four system valuation methodologies. There are:

1. Original Cost Less Depreciation (OCLD) – The OCLD value is based on the actual net book value of the distribution facilities. SDG&E, when it establishes its rates, recovers the original costs of its facilities through depreciation charges. SDG&E is then allowed to earn a return on the net book value of the distribution facilities. The OCLD method takes into account the previous customer payments for these distribution facilities. Black & Veatch requested the original cost of the distribution system in the Viejas Reservation boundary from SDG&E; SDG&E did not provide the original cost estimate.
2. Replacement Cost Less Depreciation (RCLD) – The RCLD value is based on the costs of the current facilities as if they were constructed today. RCLD is calculated on the original costs of the distribution facilities escalated to present

costs of construction using appropriate cost indices. This replacement cost is then depreciated using SDG&E's composite distribution system depreciation rate. The RCLD method recognizes, in SDG&E's favor, that the current distribution facilities would cost more today than when the system was originally built.

3. Reproduction Cost New Less Depreciation (RCNLD) – RCNLD is the cost of reproducing, or constructing, a new distribution system. The primary difference between RCLD and RCNLD is that RCNLD would utilize current technology. The current technology may be more efficient than existing equipment. For the Utility Formation Study performed in 2002, SDG&E provided a preliminary estimate of the system using this methodology. The estimated price of $3,000,000 was based on engineering costs and applied estimates of the average age of the facilities for the determination of depreciation. Further detail is required on SDG&E's estimated price. This price is ten times higher than Black & Veatch's estimate. SDG&E also did not provide any detail on payments contributions Viejas has made on these facilities.
4. Going Concern Value or Discounted Cash Flow Value – RCLD and RCNLD valuations are based on distribution systems' costs. The Going Concern valuation method is based on SDG&E's earnings from the distribution system. SDG&E's rates are designed to recover all of SDG&E's costs in providing distribution service plus a return on the distribution facilities. SDG&E's cash flow from the system is estimated by determining its annual depreciation expense (which is recovered through rates but does not have a corresponding cash outflow) and its return on equity (profit on the distribution system).

If the Tribal Utility does exercise its right of condemnation, the value of the distribution system most likely would be subject to litigation and would include RCNLD and reasonable reconfiguration costs. SDG&E has indicated that the distribution system is in good condition and is maintained regularly as a part of the SDG&E inspection and maintenance program, as required by the CPUC General Order 165. SDG&E has indicated that the underground system, most of which was built in the last five years, is generally newer than the overhead system. SDG&E did not provide precise age estimates of the system or components. Therefore, for the purposes of this study, Black & Veatch used a linear multiplier factor to estimate the value of the distribution assets. Through a cursory visual inspection of SDG&E's distribution system in the Tribal Utility's territory, the distribution system seems to be relatively new. Therefore, Black & Veatch also assumed that the valuation RCLD and RCNLD methods would be similar.

8.3.1 System Cost

OCLD

The Original Cost Less Depreciation valuation approach takes into consideration the original cost of the system, including poles, lines, transformers, and equipment, and subtracts the accumulated depreciation to obtain a value. SDG&E did not provide the Reservation's original installed costs of its respective electric distribution system assets nor did it provide an estimated accumulated depreciation of the Viejas System. Therefore, Black & Veatch employed a linear valuation method using estimated cost per linear mile for the calculation of the OCLD value.

Valuation Assumptions – assumed system to be 10 years old, assumed cost of $22,000 per mile of distribution system, assumed 16 miles of distribution circuit within Reservation boundary.

Length of system in Miles	16
Cost per mile	$22,000
Cost of System	$352,000
Less: Accumulated Depreciation (10.0 years/30 years)	33.3%
Total OCLD Estimate:	$234,784

RCLD

Building on the estimate calculated above for OCLD, the RCLD can be calculated as follows. Valuation Assumptions – assumed system to be 10 years old, assumed cost of $22,000 per mile of distribution system, assumed 16 miles of distribution circuit within Reservation boundary.

OCLD Estimate – From Section 5.5.1	$234,784
Handy Whitman Index Multiplier	1.141
RCLD Estimate	$267,889

The Base Case Distribution System Cost was assumed to be $270,000. The sensitivity analysis is as follows:

Going Concern

The Going Concern, or discounted cash flow, method provides an accurate measure of SDG&E's ability to earn income from the electric facilities. This method estimated the value of the system at approximately $15.3 million. Therefore, the Going Concern calculated value is less than the RCLD value and as a result no "added value" for the system.

8.3.2 Reconfiguration Costs

Reconfiguration Costs are those costs related to the Tribal Utility reconfiguring its system to operate separately from SDG&E. From a brief inspection it is assumed that the majority of the Tribal Utility's load will be served by one feeder. Depending on the severance scenario to be determined, SDG&E will need to confirm. For the Utility Formation Study performed in 2002, Black & Veatch requested any estimated costs for any severance damages from SDG&E for the purpose of the study; SDG&E stated that the information is proprietary and therefore SDG&E is unable to provide the requested information. Black & Veatch also requested estimated costs to reconfigure the distribution system for alternative energy deliveries from other sources and the methodology for estimating reconfiguration costs. SDG&E did not provide any estimates; however SDG&E did state that any estimate of a reconfiguration cost should include costs of severance from the remaining SDG&E system and costs associated with interconnection facilities through which power would be delivered to Viejas. Black & Veatch addresses the issues in three scenario analyses described in Section 7.0.

9.0 Legal Analysis

The Legal Analysis section is included as Appendix D of this report.

10.0 Generation Mix Optimization Study

Black & Veatch's generation optimization process involves several steps. First, the technologies identified in Section 5.0 of this report are evaluated economically using a Levelized Cost Approach. Then, remaining technologies are further evaluated using Black & Veatch's software POWROPT, an optimal generation expansion model. Specific scenarios are further evaluated using the production cost model POWRPRO.

The production cost and capital cost results are taken directly from POWRPRO and POWROPT and serve as the cost assumptions for the economic analysis performed in Section 13.0. Figure 10-1 is a flowchart of the Optimization Process.

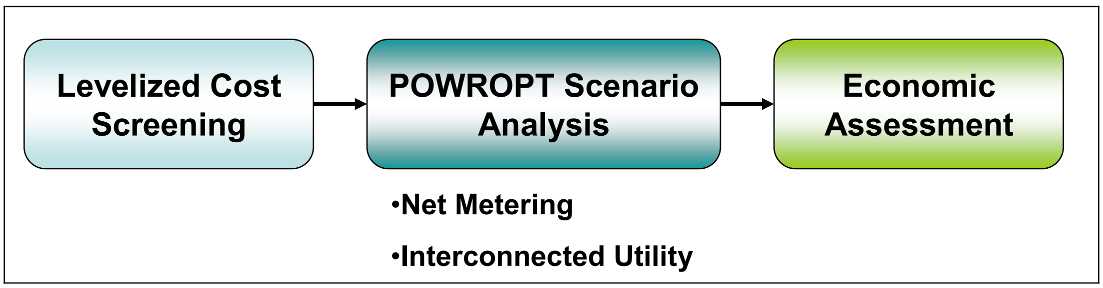

Figure 10-1. Optimization Process

10.1 Optimization Process

10.1.1 Levelized Cost Screening

The assumptions described in Section 5.0 are used to calculate the Levelized Cost of each Renewable Technology option. The levelized cost is calculated as the average cost in cents/kWh for the life of each technology. Key assumptions used in the calculation include the following:

- Max Output, MW
- Capital Cost
- Debt Term
- Economic Life
- Fixed O&M, $/kW-yr
- Variable O&M, $/MWh
- Capacity Factor
- Production Tax Credit
- Term of Production Tax Credit
- Fuel Cost
- Net Plant Heat Rate
- Discount Rate
- Fixed Charge Rate

The assumptions are consistent with those used in the economic analysis performed in Section 13.0. Each technology's levelized cost is calculated using the above assumptions, as well as the range of potential capacity factors for each technology.

The results are used to screen out technologies that will not be selected by POWROPT. This screening allows the optimization model to converge to an optimal solution in a manageable timeframe. Black & Veatch screened out technologies that, based on the assumptions used, would not be competitive with (a) the prices currently being paid for power through SDG&E and (b) the other technology options under evaluation.

10.2 Planning and Production Costing Methodology

The supply-side evaluations of generating unit alternatives were performed using POWROPT, an optimal generation expansion model. POWROPT, developed by Black & Veatch, has been benchmarked against other optimization programs and has proven to be an effective modeling program. POWROPT, and its production costing module POWRPRO, have both been used in numerous power supply planning and integrated resource plan engagements across the country.

POWROPT, which operates on an hourly chronological basis to determine a set of optimal capacity expansion plans, simulates the operation of each of the expansion plans, and selects the most desirable plan based on cumulative present worth revenue requirements. POWROPT evaluates all combinations of generating unit alternatives and purchase power options while maintaining user-defined reliability criteria. All capacity expansion plans were analyzed over the 20 year period from 2006 through 2025.

After the optimal generation expansion plan was selected using POWROPT, Black & Veatch's detailed chronological production costing program, POWRPRO was used to obtain the annual production cost for the expansion plan. POWRPRO is a computer based chronological production costing model developed for use in power supply systems planning. POWRPRO simulates the hour-by-hour operation of a power supply system over the specified planning period. Required inputs are carried forward from those used in POWROPT and include the performance characteristics of generating units, fuel costs, and the system hourly load profile for each year.

POWRPRO summarizes each unit's operating characteristics for every year of the planning horizon. These characteristics include, among others, each unit's annual generation, fuel consumption, fuel cost, average net operating heat rate, the number of hours the unit was on-line, the unit's capacity factor, variable O&M costs, the number of starts and associated fuel costs. Fixed O&M costs are also included for new unit additions. The operating costs of each unit are aggregated to determine annual operating costs for each year of the expansion plan, and capital costs, fixed O&M, fixed costs for natural gas transportation, and capacity charges associated with new unit additions and new purchase power alternatives are then added. The cumulative present worth cost (CPWC) of each expansion plan is then calculated.

The CPWC calculation accounts for annual system costs (fuel and purchased energy costs, fixed and variable non-fuel O&M, purchase power capacity charges and other fixed charges, natural gas transportation charges, and levelized capital costs) for each year of the expansion planning period and discounts the costs back to 2006 at the present worth discount rate of 5.5 percent. These annual present worth costs are then summed over the 20 year period to calculate the total CPWC cost of the expansion plan being considered. Such analysis allows for a comparison of CPWC between various capacity expansion plans, and the plan with the lowest CPWC is considered the least-cost capacity expansion plan.

10.3 Key Assumptions Overview

The Generation Technology Assumptions developed in Section 5.0 were used to characterize the performance and cost assumptions for each option evaluated in the optimization process.

The Annual Energy Profile developed in Section 3.0 is another key assumption used in the optimization model. Black & Veatch's Load model was used to take the typical 8,760 hour energy profile for Viejas, and grow it annually. The peak demand and energy for each year is consistent with the assumptions in Section 3.3.

In evaluating wind technologies, the wind data analyzed in Section 5.0 was used to evaluate different wind technologies. Annual 8,760 hour wind energy curves were developed as an input to POWRPRO.

In evaluating solar technologies, the solar data analyzed in Section 5.0 was used to evaluate technologies. Annual 8,760 hour solar energy curves were developed as an input to POWRPRO.

10.4 Levelized Cost Screening Results

Figure 10-2 shows the range of likely Levelized Cost for each technology. The ranges are driven by the potential range in annual capacity factor, as well as cost assumptions. Important assumptions used in this analysis include:

- For wind technologies, capacity factors were calculated using the wind data collected as part of this project and detailed in Section 5.1.
- Solar capacity factor assumptions are consistent with the analysis performed in Section 5.2.

- All financial assumptions are consistent with those used in Section 13.0, Economic Assessment.
- The fuel cost assumptions for the Microturbine Cogeneration option take into account the value of waste heat from the turbine that would be used to offset current heating load.
- The fuel cost assumptions for the conventional gas simple cycle option assume that a portion of the waste heat generated by the turbine is used to offset current heating load.
- The abbreviation SGIP stands for Self Generation Incentive Program, a California program, funded by the PUC, which provides capital cost incentives for investment in self generation.
- The Pumped Hydro levelized costs are dependent on the Small Wind Farm option being implemented in tandem. The Stand Alone Utility Planning Scenario will require redundant generation sources that minimize the probability of loss of load. Therefore, the combination of a small wind farm and pumped hydro would be considered for this planning scenario. These options are not evaluated in either the Net Metering or Interconnected Utility planning scenarios.

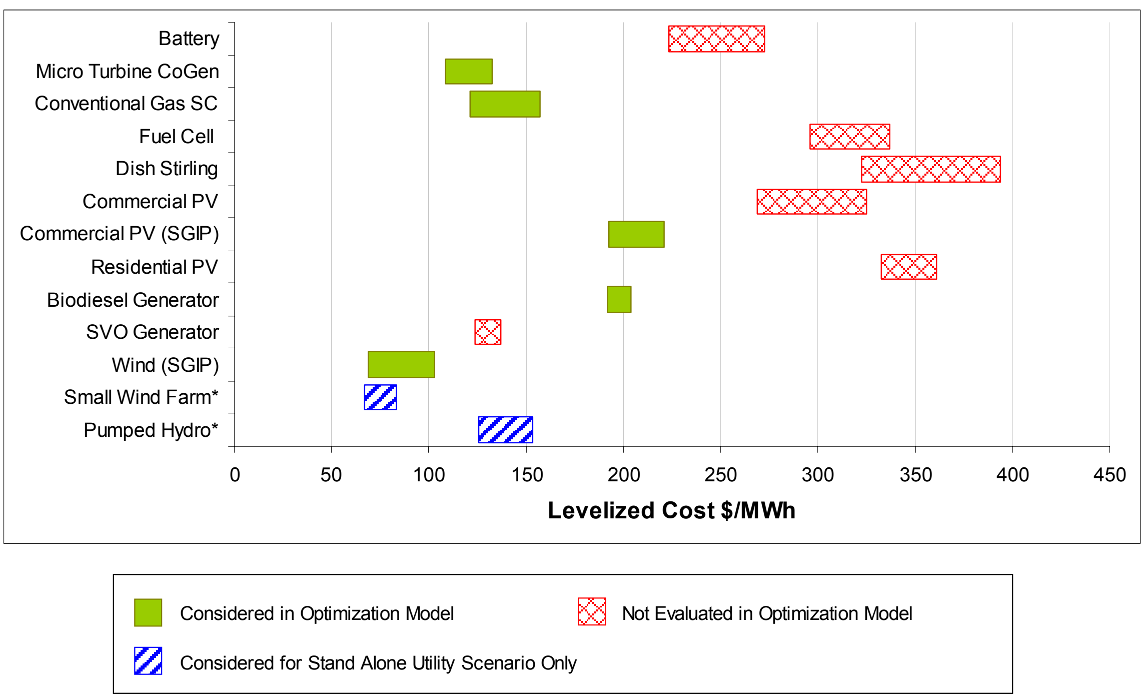

Figure 10-2. Levelized Cost Results

* The assumptions used for the Small Wind Farm and Pumped Hydro are dependent on both technologies being installed on the El Capitan Reservation.

Based on the assumptions used, the levelized cost of the technologies highlighted in checkered red are uneconomic in comparison to the other options, as well as in comparison to the rates Viejas is currently paying for electricity. Therefore, these options were not evaluated further in the optimization process.

While the economics of the SVO Biofuel technology are promising, since it is currently an unproven generation technology, it was not considered as a viable option for the optimization process. However, should thermal generation sources be pursued by Viejas in the future, this technology does merit investigation.

10.5 Evaluation of Planning Scenarios

Two planning scenarios were evaluated within the optimization model. These included scenarios for the following two strategic options discussed in Section 3.0:

- Net Metering
- Interconnected Utility

In discussions with Viejas Tribal Government, it was decided that there was a low probability of siting renewable generation on the Capitan Grande Reservation. Since the siting of generation on the Capitan Grande Reservation would likely be required to viably develop a Stand Alone Utility, this option was not evaluated using the optimization model.

10.5.1 Net Metering

For the net metering planning scenario, in addition to the renewable technology generation options, the optimization model also has the option to purchase electricity from SDG&E. The rate assumed for these purchases is equivalent to the weighted average aggregate price Viejas currently pays SDG&E, inclusive of Energy and Demand charges. This aggregate rate was calculated using recent billing information to be 11.4 cents per kWh.

Analysis of Viejas demand data identified three meters with high usage that would lend them to an effective net metering situation. These meters include the following:

Account Number	Meter Number	Meter Abbreviation	Name
9678664455	1818617	A	VIEJAS CASINO & TRF CLB
655391861	1667537	B	VIEJAS CASINO & TRF CLB
3882914171	1751731	C	VIEJAS CASINO & TRF CLB

Meter 'A' has had an annual average demand of over 1 MW historically. Meters 'B' and 'C' as they will be referred to in this section, both have average annual demand of over 400 kW, with peak levels significantly higher than this average level.

As Figure 10-2 demonstrates, only one renewable generation technology's levelized cost is less than the 11.4 cent/kWh weighted average cost of electricity. Therefore, for the base case net metering planning scenario assumptions, the only generation technology with the potential for a positive cash flow is wind generation. The following three wind turbine net metering scenarios were further analyzed in the Economic Assessment:

- A single 1 MW wind turbine, net metering against Meter A
- Two 1 MW wind turbines, net metering against Meters A & B
- Three 1 MW wind turbines, net metering against Meters A, B, and C

These scenarios were simulated using the POWRPRO production cost model. The results of these production cost model simulations are used as cost inputs in the economic analysis performed in Section 13.0. The policies governing both net metering and the SGIP program do have limits to what can be done at a single site or by a single owner. How these rules apply to these three meters was not specifically analyzed at this time. The study assumes all three turbines receive the SGIP capital cost credit. The two and three turbine scenarios should be considered contingent on meeting the regulatory requirements governing the program.

10.5.2 Interconnected Utility

The optimization model was used to evaluate the option of developing a utility that is interconnected with the grid. The technology options that were economically competitive based on the levelized cost screening analysis were further evaluated using POWROPT.

In contrast to the Net Metering option, for this planning option all of Viejas' demand is aggregated. The options that the optimization model has to choose from to serve the demand include the viable renewable technology options, as well as purchased electricity available from the grid.

The assumed price for purchased power is 6.87 cents per kWh in 2005. This price does not include any cost of CDWR premiums. These premiums are described more fully in Section 13.0 as they are one of the risk factors evaluated in the Economic Assessment.

As Figure 10-2 demonstrates, none of the renewable technology option levelized costs are less than the 11.4 cents per kWh currently being paid for electricity to SDG&E.

Two options with the potential for greater economic viability include the combination of a pumped hydro facility and small wind farm installed near the Capitan Grande Reservoir. Due to jurisdictional and political issues, this site was not evaluated for this feasibility study.

As a result, the optimal base case interconnected utility plan is to purchase electricity at the purchased power rate of 6.87 cents per kWh for all of Viejas' requirements. This plan was simulated using POWRPRO and the results used as inputs to the economic analysis section.

11.0 Environmental Assessment

11.1 Wind

Wind is a clean generation technology from the perspective of emissions. However, there are environmental considerations associated with wind turbines. First, opponents of wind energy frequently cite visual impacts as a drawback. Some turbines are approaching and exceeding 300 feet tall, and for maximum efficiency tend to be located on ridgelines and other elevated topography. Combining turbines of different type, manufacturer, color and rotation can increase the visual impact of turbine developments. Second, turbines can cause avian fatalities if they are located in areas populated by native birds or on migratory flyways. To some degree, these issues can be partially mitigated through proper siting, environmental review, and the involvement of the public during the planning process.

11.2 Solar

A key attribute of solar PV cells is that they are virtually non-polluting after installation. Some thin film technologies have potential for discharge of heavy metals in manufacturing; however, this issue is being adequately addressed through proper monitoring and control. Compared to emissions from conventional fossil fuel technologies, these impacts are generally inconsequential. The main impact of large PV installations is occupation of land area. This problem is avoided with rooftop and parking structure installations.

11.3 Biodiesel

When compared to petroleum diesel, biodiesel offers a variety of benefits. Testing has shown that biodiesel has lower sulfur emissions and particulate emissions than regular diesel fuel. Not only does biodiesel emit few harmful gases when combusted, but in almost every circumstance, fewer greenhouse gases are emitted in the production and transportation of biodiesel than are released in the production, transportation, and refinement of petroleum diesel. In addition to the aforementioned benefits, biodiesel boasts higher full-fuel cycle efficiency.

Straight vegetable oil (SVO), while still being a carbon neutral fuel and sharing most of the emission reduction characteristics of biodiesel, does have greater particulate and un-burnt carbon emissions than biodiesel. Whether using biodiesel, SVO, or natural gas the air quality impacts and regulations will need to be addressed as an early step in their development.

11.4 Pumped Hydro

Pumped hydro has the potential to impact fish populations in either the upper or lower reservoir. Proper screening to exclude fish from being drawn into pumps and turbines can eliminate most of this impact. The upper reservoir may have extreme variations in level depending on its volume in comparison to use patterns. The creation of an upper reservoir in Capitan Grande reservation will require flooding of an area of land. This could be seen as an impact or an environmental positive through adding aquatic habitat, though the quality of that habitat will be compromised due to the varying reservoir levels.

11.5 Cleveland National Forrest

The renewable energy technology options considered in this feasibility study will have little or no effect on the Cleveland National Forest, with the following exceptions:

- Development of a pumped hydro facility will have minor effects on lake levels in the Capitan Grande Reservoir, and effects on fish in the reservoir will need to be addressed in the design of the pump intake system.
- A pumped hydro or wind farm installation within the Capitan Grande Reservation will require road and transmission access across the Cleveland National Forest. Road and transmission tower installation can have some erosion and visual impact effects on the national forest.
- A wind farm on the Capitan Grande Reservation will impact the view from high points within Cleveland National Forest.
- Any thermal generation will have some level of air quality impact to the surrounding area.

12.0 Tribal Benefit Assessment

The purpose of the Tribal Benefit Assessment is to evaluate the impacts of renewable energy development choices to the tribe for the following issues:

- Employment
- Cultural
- Social

The potential of developing renewable energy on Viejas land was assessed for these issues to ensure it aligns with Viejas Tribal values and to evaluate the influence of development on the tribe.

12.1 Employment

One potential tribal benefit to renewable energy installations is employment. A tribal utility requires trained staff and sound management to carry out distribution system operations and maintenance (O&M). O&M operations include repairs and replacement of the components, such as lines, cables, poles, transformers, that make up the distribution system. Additional operations are tree trimming, vegetation control, new service/expanded service construction, and emergency restoration services.

The Tribal Government may elect to develop its own crews, contract with private companies, or contract with neighboring utilities for the performance of O&M responsibilities.

In addition to the care of the distribution system, the Tribal Government will need to provide customer service and billing services. Plans must be made for the provision of basic customer services such billing, collections, meter reading, new account establishment and discontinuance of service. Again, the Tribal Government may elect to provide its own personnel to perform these services and incorporate the systems with those used for water management or contract with other parties. Because of the small size of the utility's client base, the lack of internal mechanisms for O&M and customer service, and the close proximity of contractible resources, this evaluation assumes that the Tribal Government will contract the entire operation with a third party supplier.

12.2 Cultural Issues

One of Viejas' cultural values includes the Right of Self Determination. Investment in and operation of energy production facilities, specifically renewable technology, aligns with this value. Many of the technologies evaluated in this study allow the tribe to gain varying degrees of energy independence. Fuel sources for many of the renewable technologies are inherent in nature and decrease the impact that fossil fuel and electric market volatility have on Tribal Energy Usage and Cost. Greater energy independence allows the tribe greater control over its future energy decisions.

12.3 Social Issues

The issue of environmental stewardship is one directly and significantly affected by energy usage. Investment in renewable energy sources decreases the demand for fossil-fuel fired electric generation, which releases greater amounts of emissions into the environment. Tribal reliance on renewable energy sources ensures that tribal energy consumption is contributing to a more healthy and safe environment, one of Viejas' tribal values.

Renewable energy provides tribal educational opportunities for the tribe and its neighbors. One way to promote this education would be the development of a Renewable Energy Education Center.

13.0 Economic Assessment

Black & Veatch investigated the feasibility of Viejas acquiring the portion of SDG&E's electric distribution system within Tribal Government borders, in order to provide power cost savings to the Tribal Utility's customers. This section outlines the feasibility of the two planning scenarios discussed in Section 10.5. The financial models used for the two evaluations are included in Appendix C of this report.

13.1 Economic Assessment of Planning Scenarios

13.1.1 Net Metering Planning Scenario

As discussed in Section 10.5, the following three scenarios were evaluated economically using the financial model:

- A single 1 MW wind turbine, net metering against Meter A
- Two 1 MW wind turbines, net metering against Meters A & B
- Three 1 MW wind turbines, net metering against Meters A, B, and C

The results of the Net Metering Planning Scenario analysis indicate that of the three scenarios, the option to install three 1 MW wind turbines for net metering against Viejas' largest three meters has the highest 10 year Net Present Value (NPV). Under this scenario's Base Case, the 10-year cash flow analysis yields an NPV of $651,000. Risk factors to this scenario are evaluated in Section 13.2.1.

While the base case analysis for the three turbine scenario yields the largest NPV, Black & Veatch notes that the policies governing both net metering and the SGIP program do have limits to what can be done at a single site or by a single owner. How these rules apply to these three meters was not specifically analyzed. The study assumes all three turbines receive the SGIP capital cost credit. The three turbine scenario should be considered contingent on meeting the regulatory requirements governing the program.

The following tables show the 10 year NPV results for one and three turbines, respectively, in addition to the capital costs for each option.

Option	10 Year NPV	Capital Cost (after SGIP)
Net Metering – 1 WT	$223,000	$700,000
Net Metering – 3 WT	$651,000	$2,100,000

13.1.2 Interconnected Utility Planning Scenario

Black & Veatch analyzed the Tribal Utility's proposed purchase of the electric distribution system using a cash flow model. Black & Veatch started its analysis by establishing a Base Case Scenario. This Scenario establishes the most likely case with market and load data provided at the time of this report.

The 10 year net present value cash flow analysis shows that for the base case assumptions used, the formation of an electric utility is not economically viable. The base case scenario for the economic assessment assumes no renewable generation is installed by Viejas. For the interconnected utility planning scenario, the base case yields the most attractive 10 year NPV when compared to the renewable generation alternatives. The 10 year NPV for this base case is negative $1,929,000.

While the 10 year NPV is negative, the base case utility formation scenario does have a positive net present value in year twenty-two. Utility formation risk factors for this base case scenario are evaluated in Section 13.2.2.

13.2 Sensitivity Analysis

13.2.1 Net Metering Sensitivity Analysis

Many of the risk factors of forming a tribal utility do not apply to a net metering plan. Table 13-1 lists each of the risk factors evaluated for the base case net metering option, as well as their low and high sensitivity values.

Table 13-1. Net Metering Base Case Input Assumptions.

Parameter	Base Case	Low	High
Supply Costs ($/kWh)	1.14	1.083	1.197
Debt Financing (%)	8	7	9
Discount Rate (%)	5.5	4.5	6.5
Rate Increase/(Decrease) (%)	0	-5%	+5%
Wind Turbine Capacity Factor (Net Metering Option)	13%	8%	16%

Base Case Net Metering (3 WT) 10 Year NPV: $651,000

The sensitivity analysis shows that the major financial impact for the Tribal Utility to the base case net metering scenario is wind turbine capacity factor, as shown in Figure 13-1. Black & Veatch recommends continued monitoring of wind data using the anemometers, as discussed in Section 5.1.

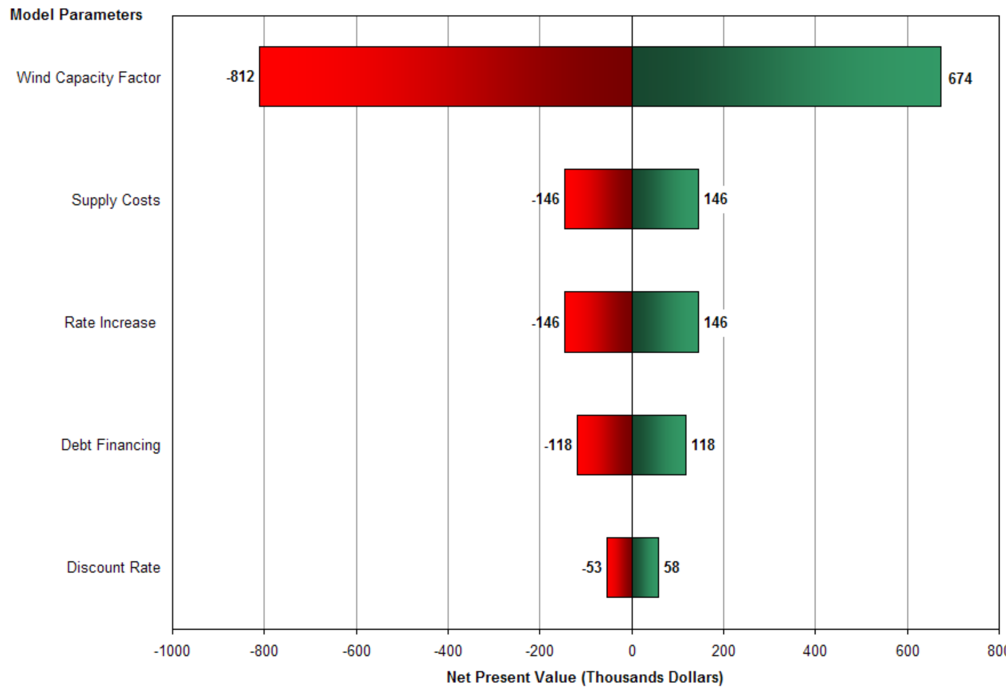

Figure 13-1. 10 Year Net Metering Net Present Value (NPV).

13.2.2 Interconnected Utility Sensitivity Analysis

Black & Veatch analyzed the Tribal Utility's proposed purchase of the electric distribution system using a 10-year cash flow model. Black & Veatch then established the parameters for which sensitivity analyses would be performed. A high and low case Scenario was developed for each of the parameters. These parameters are discussed in detail in the Utility Formation Study performed for Viejas by Black & Veatch in 2002.

Each Scenario was compared to the Base Case to determine its specific impact to the Base Case model run. A summary of the list of parameters and the high/low Scenarios is outlined in Table 13-2, Model Input Assumptions.

Table 13-2. Model Input Assumptions.

Parameter	Base Case	Low	High
Supply Costs ($/kWh)	0.0687	0.05496	0.92135
Value of System ($) (excluding legal fees)	$270,000	$234,000	$355,000
Growth Rate In MWh (%)	1.7	1.1	2.5
Growth Rate In Customers (%)	3.0	2.1	3.9
Debt Financing (%)	8	7	9
Inflation Capital Replacement (%)	1.50	1.00	2.00
Discount Rate (%)	5.5	4.5	6.5
Reconfiguration Costs ($)	5,440,000	250,000	986,000
Operation & Maintenance (2002 Contract Year)	300,000	150,000	450,000
Operation & Maintenance Cost Escalation (%)	1.0	0.5	1.5
Rate Increase/(Decrease) (%)	0	-5%	+5%
Legal Expenses ($)	2,500,000	1,500,000	3,000,000
Capital Replacement (%)	3.5	3.0	4.0
Public Goods Charge	0%	0%	2%
Wind Turbine Capacity Factor (Net Metering Option)	13%	8%	16%

Base Case 10 Year NPV: ($1,929,000)

The following chart summarizes the impact of each parameter to the Base Case NPV. The chart is split into two sections, Model Parameters and Regulatory Risks. Model Parameters shows the impact of varying operating and purchase price parameters to the Base Case. The bottom part of the chart shows the impact of Regulatory Risks associated with the Utility effort. The Base Case NPV of ($1,929,000) is shown on the chart as 0.00.

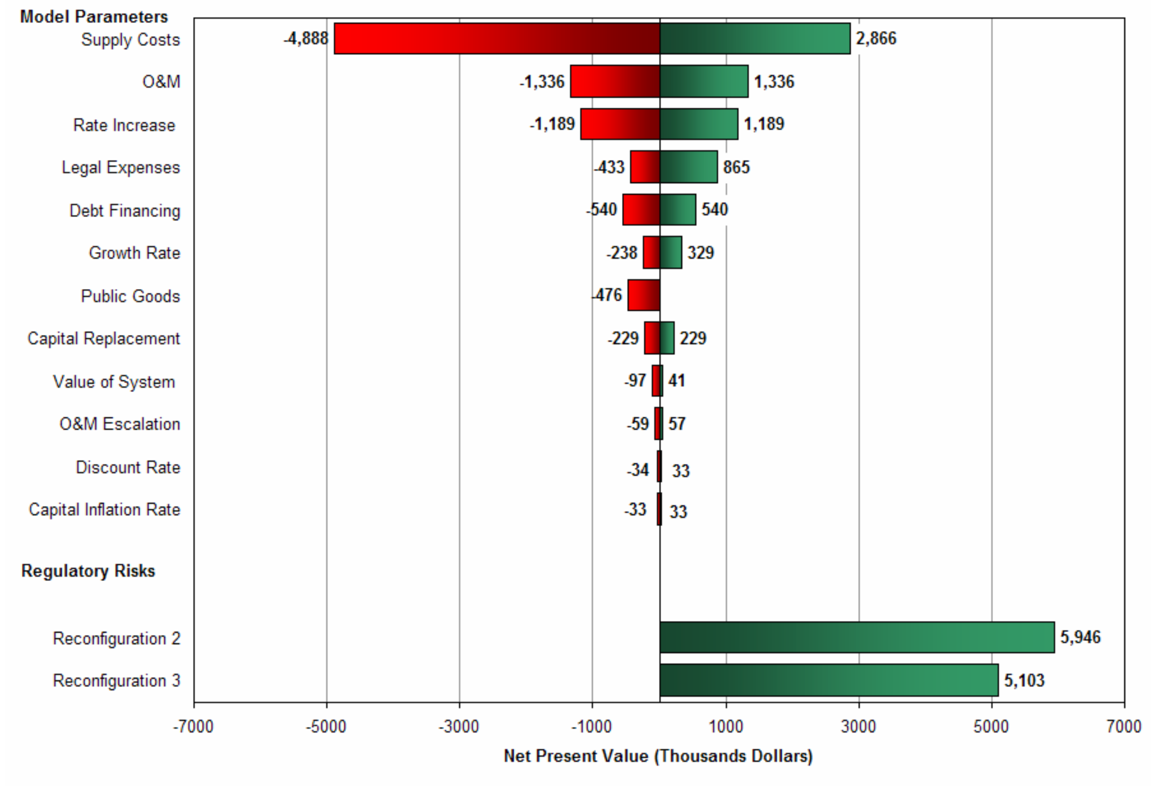

Figure 13-2. 10 Year Utility Net Present Value (NPV).

The major financial impacts for the Tribal Utility to form an electric utility are, in order of maximum NPV impact: Energy Supply Costs (Note that the High Case includes 'Stranded Costs' from DWR contracts), Operations & Maintenance, Rate Increase, and Reconfiguration Costs 2 and 3. Each parameter is discussed in the Utility Formation Study performed for Viejas Tribal Government by Black & Veatch in 2002.

The largest NPV driver for the base case scenario is Supply Costs. The base case financial model indicates that supply costs of $59/MWh or less would yield a positive 10 year net present value.

14.0 Business Plan

The following section outlines a path toward greater energy self reliance for Viejas. The path has three distinct stages. In the first stage, energy efficiency and load dispatch improvements are made as well as energy generation on an individual meter-by-meter basis. The second stage involves creating an electrical utility, coordinating energy dispatch activities between meters and installing central generation. In the third stage, Viejas would add sufficient generation and storage to meet all of the reservation's electrical needs and even export energy to the grid. These provide a potential implementation plan on the path to self generation. Section 14.4 is an outline of a traditional business plan suitable for this type of endeavor.

14.1 Self Generation/Net Metering Projects

A straight forward initial step to energy self sufficiency is to implement some smaller to mid-sized generation projects. These projects should be the most economical and politically feasible projects. Load reduction and load management projects are likely to be the most economical projects. The feasibility analysis indicates wind turbine projects at the site of major loads will likely have a comparable cost of energy to current electric rates. Though not providing the least expensive energy solar PV is very well accepted in the community and the non-economic value of PV installation(s) may merit their inclusion for early development.

Several next steps are identified should Viejas choose to pursue this planning scenario:

- Identify and implement cost effective energy efficiency projects
- Identify and implement economical load management strategies
- Begin pre-development of wind project
- Get quotes for wind turbine installation and select contractor
- Install wind turbine(s)
    - Engineering Design
    - Power Agreement
    - Permitting and Licensing
    - Project Financing
    - Hardware Development
    - Construction and Training
    - Commissioning
    - Operations & Maintenance

- Identify and evaluate potential solar PV projects.
- Select and implement PV project(s)

14.2 Utility Formation

Should Viejas choose to form a tribal electric utility, it will be possible to negotiate a bulk power agreement for the entire reservation. Furthermore load management across the entire reservation is possible as well. In addition, generation at a particular site is no longer limited to the consumption at that particular meter. With the formation of a utility, installation of a small natural gas (or waste vegetable oil) fired combustion turbine may have advantages, especially if use can be made of the waste heat. A SCADA system to enable generation and load dispatch will be helpful for Viejas in managing a utility. The following steps should be taken, should Viejas choose to form an electric utility:

- Issue a Request for Proposals for power supply to the new electric Utility
- Obtain a legal opinion on the optimal electric utility structure and condemnation process
- Investigate opportunities to include additional adjacent electric load
- Issue a Request for Proposals for operation, maintenance, and customer service support for the new electric utility
- Develop a communications plan for the community to explain issues, process and reasons why Viejas is proceeding with forming an electric Utility
- Investigate:
    - Absorption Chillers and other waste heat users
    - Load and Generation Integration
    - Additional Renewable Technology at Quality Sites

14.3 Self Sufficiency

It will be expensive to obtain energy self sufficiency using renewable energy sources on the Viejas reservation. The wind resource is marginal and though the solar resource is very good, the cost to develop solar electricity is high. Unless biomass would be imported from off site, renewable dispatchable generation or energy storage will also be expensive.

It may be that product advancement, or strong incentives will make development of a large scale solar thermal electric plant at Viejas attractive in the future.

It has been indicated that Viejas may at some point in the future gain rights to develop the Capitan Grande Reservation. The Capitan Grande Reservation has two features which would increase the viability of a self sufficient Viejas Renewable Energy Tribal Utility. First, the wind resource is much better than on the valley floor, making a commercial wind farm viable. Second, access to the Capitan Grande reservoir would enable construction of a pumped hydro storage facility with a water storage pond constructed on high ground within the Capitan Grande Reservation. In this scenario wind energy would be the primary energy source for the reservation. Pumped water would store energy to be released when the wind is not blowing.

General steps to achieve an energy self-sufficient Viejas through development of a wind farm and pumped hydro storage facility are listed below.

- Create conceptual design
- Build community support
- Identify requirements and begin permitting
- Identify customer(s) for excess energy begin negotiations
- Identify contractors for wind farm and hydro construction, get bids
- Construct wind farm and hydro facility
- Connect output to Viejas grid
- Maintain and operate system

14.4 Business Plan Outline

It will be beneficial to the development of renewable energy at Viejas for the Public Works Department, with Black & Veatch support, to build a business plan including elements from the outline below based on this report, continuing Black & Veatch support, and tribal member and government input once a direction has been decided on.

- Statement of Purpose
- Tribal Electric Utility
    - Description of the Utility
    - Legal structure
    - Functions
    - Personnel
    - Management
- Communications Plan
- Financing
- Financial Forecast
    - Expenses
- Revenue