A Feasibility Study of Sustainable Distributed Generation Technologies to Improve the Electric System on the Duck Valley Reservation

DRAFT FINAL

December 2004

Submitted to the US Department of Energy in Response to:
DE-PS36-02GO92006
Renewable Energy Development on Tribal Lands

Submitted by:
Shoshone-Paiute Tribes of the
Duck Valley Reservation

Business Contact:
Herman Atkins, Tribal Programs Administrator
Duck Valley Reservation
PO Box 219
Owyhee, NV 89832
775 757-3161
dvir4@aol.com

Technical Contact:
Mark Hannifan
New West Technologies, LLC
383 Inverness Parkway, Suite 330
Englewood, CO 80112
303 792-3736
303 792-3759 (fax)
hannifan@newwesttech.us

TABLE OF CONTENTS

	Page
1.0 BACKGROUND	**2**
2.0 ASSESSMENT OF THE ELECTRIC DISTRIBUTION SYSTEM (PART 1)	**3**
2.1 Overview of Current Electric Distribution System	**3**
2.2 Part 1 Assessment Tasks	**3**
2.3 Identification and Characterization of System Reliability and Deliverability Problems	**4**
2.4 Strategies for Improving Electric Distribution System Reliability	**4**
2.5 Assessment of Energy Efficiency Opportunities	**4**
3.0 ASSESSMENT OF SUSTAINABLE DG TECHNOLOGIES (PART 2)	**5**
3.1 Part 2 Assessment Tasks	**5**
3.2 Wind Power	**5**
3.2.1 Overview of Previous Wind Resource Characterizations at Duck Valley	**5**
3.2.2 Overview of Current Wind Resource Characterizations at Duck Valley	**8**
3.2.3 Results of Wind Resource Data Collection at Duck Valley	**9**
3.2.4 Next Steps for Duck Valley Wind Development Efforts	**11**
3.3 Solar Power	**12**
3.4 Fuel Cells	**13**
4.0 SUMMARY OF BENEFITS/BARRIERS AND IMPLEMENTATION REQUIREMENTS	**14**
4.1 Benefits and Barriers	**14**
4.2 Required Steps for Project Implementation	**14**
APPENDIX A LIGHTING INVENTORY DATA FOR DUCK VALLEY BUILDINGS	**17**
APPENDIX B WIND ANALYSIS SUMMARY REPORTS (MILLER CREEK SITE)	**37**

1.0 BACKGROUND

The 453 square mile Duck Valley Indian Reservation, home to bands of the Shoshone and Paiute Tribes, straddles the Nevada-Idaho borders and is situated in one of the most remote and thinly populated areas of the lower 48 states. The Reservation is home to about 1,100 people, with an unemployment rate of about 40%.

Land within the Reservation is fairly diverse, ranging from the Owyhee River Valley up into high desert country and mountains. Because of its high desert climate, the Reservation is blessed with high annual average solar radiation (90%+ days with sunshine in summer, ~70% days with sunshine in winter) and several areas of the Reservation experience high annual average wind speeds.

The electric distribution system that feeds the Reservation has been chronically susceptible to outages, and multi-day system outages are not uncommon due to the remoteness of the lines. The main feeder line serving the Reservation is also rapidly approaching its capacity limit. Both of these factors have negatively affected the Tribes' plans to promote economic development on the Reservation.

In response to these power issues, the Tribes' recently developed *Economic Development Strategic Plan* identified the need for an assessment of the potential for alternative energy technologies to improve the reliability and deliverability of electric power on the Reservation. With funding support from the US Department of Energy's (DOE) Tribal Energy Program, the Project Team conducted *A Feasibility Study of Sustainable Distributed Generation Technologies to Improve the Electric System on the Duck Valley Reservation* in two parts:

- An assessment of the electric distribution system serving the Reservation, including a review of on- and off-Reservation power lines and substations, an inventory and characterization of on-Reservation electrical loads, and an assessment of electrical energy efficiency improvement opportunities;

- An assessment of the technical and economic feasibility of renewable-based distributed generation technologies including wind turbines, solar photovoltaics, and stationary fuel cells.

The assessment was conducted as a partnership of the Duck Valley Tribes, New West Technologies of Englewood, Colorado CSHQA of Boise, Idaho, Idaho National Environmental Engineering Laboratory, and the Idaho Department of Water Resources.

2.0 ASSESSMENT OF THE ELECTRIC DISTRIBUTION SYSTEM (PART 1)

2.1 Overview of Current Electric Distribution System

In response to high unemployment and the desire to expand economic development on the Reservation, the Duck Valley Tribes are pursuing initiatives in the areas of agriculture/ranching, outdoor recreation and tourism, and downtown revitalization. An impediment to these economic development initiatives, however, is the Reservation's electric distribution system.

Duck Valley Reservation is at the "end of the line" in terms of electric service. The Reservation is served by a single 34.5 kV distribution line that originates at a substation in Mountain City, Nevada (12 miles off the Reservation to the southeast) and dead ends on the Reservation.[1] No other electric interconnect option is available within 60 miles. The 69 kV transmission line upstream of Mountain City (some sections of which were constructed in the 1930s) is chronically susceptible to outages, with the Reservation experiencing as many as 12 outages per year lasting over 8 hours per outage.

The distribution system serving the Reservation is also rapidly approaching its capacity limit. The 69/34.5 transformer at Mountain City substation is rated at 6.25 MVa, and system loads on the Reservation have recently approached 6.0 MVa in the winter.[2] These values indicate that there is available capacity for about 0.25 MVa (or ~250 kW) of additional load on the distribution side of the substation (i.e. the Reservation). As a result, Raft River Electric Cooperative (RREC) previously advised the Duck Valley Tribes that a proposed retail center (now built) on the Reservation with an estimated peak load of 200 kW would exceed RREC's ability to provide full electric service to the Reservation. This chronic uncertainty of deliverability of electricity has clouded the Tribes' ability to plan other economic development or infrastructure improvement initiatives.

2.2 Part 1 Assessment Tasks

The first part of the *Study,* as it was originally proposed, involved an assessment of the current electric distribution on the Reservation. In Part 1 the Project Team:

- ❑ identified the sources of the reliability and deliverability problems;

[1] In 2001, Idaho Power sold the distribution system on the Reservation to Raft River Electric Cooperative whom maintains the system.

[2] Duck Valley Reservation electric loads peak in winter due to widespread reliance on electric space heating and electric water heating in buildings.

- conducted an assessment of utility bill data and other data available from RREC to determine the magnitude, hours of operation, and coincidence of electric loads on the Reservation (by location and end use) and the intensity of electricity use (e.g. kW/ft2, kWh/ft2);

- identified opportunities for deployment of energy efficiency or load reduction measures in buildings and other electric end use applications.

2.3 Identification and Characterization of System Reliability and Deliverability Problems

From a review of a RREC "dispatch outage report" associated with the Mountain City substation for the period 1996 to 2002, area-wide power disruptions were primarily caused by four types of events: 5 power disruptions due to "equipment failure", 4 due to "maintenance", 44 due to "loss of supply", and 5 due to "load shedding". The predominant reason by far for power disruptions at the Mountain City substation (and thus on the Duck Valley Reservation) was the loss of upstream electric supply, due mainly to weather-induced failure (e.g. icing, high winds, etc.) of the aging transmission system between the Jarbridge (NV) substation and Mountain City. The "dispatch outage report" also was an early indicator of the carrying capacity constraints that now impact the Reservation as the power disruptions caused by "load shedding" were not evident from 1996 to 2000, but began to occur early in 2001. The possibility of "load shedding" power disruptions continues today, particularly in winter peak electric demand periods.

2.4 Strategies for Improving Electric Distribution System Reliability

It was the project team's original intent to pursue discussions with RREC about corrective strategies for improving reliability/deliverability of the existing radial feed system, starting on the Reservation and working upstream. However, soon after startup of the *Study*, RREC announced that it had received a major grant from the USDA's Rural Utility Service (RUS) to construct a 138 kVa line to the Reservation which would enable the 34.5 kVa distribution system on the Reservation to be interconnected to an entirely new and lightly loaded transmission/distribution system from the north.[3] Once built in 2007, this new power line will greatly improve both the reliability and deliverability of electric power to the Duck Valley Reservation.

2.5 Assessment of Energy Efficiency Opportunities

In an effort to address, in part, the severe constraints for accommodating economic (and thus electric demand) growth on the Reservation, energy audits (with a lighting emphasis) were conducted on the major institutional buildings on the Reservation to determine the potential for reduction of electricity use and electric demand. Room-by-room walkthrough audits of the buildings were conducted in July 2004 to develop inventories and characterizations of existing lighting equipment. Based on the inventories and characterizations, high efficiency replacement equipment was analyzed for electricity and electric demand savings, installation cost, and economic payback.

Appendix A provides a listing of existing lighting equipment and their characteristics for the buildings audited on the Duck Valley Reservation. Appendix A also provides a building-by-building summary of the results of proposed lighting retrofits. In general, a vast majority of the lighting fixtures in the major buildings on the Reservation use previous generation fluorescent lighting technology (i.e. magnetic ballasts and T12 lamps). Further there is a high degree of commonality among the lighting fixtures, meaning that the strategies for retrofitting fixtures can be replicated from building to building.

---

[3] The projected cost of the new line is $7.5 million, of which RREC is contributing ~ $2.3 million, the Duck Valley Tribes are contributing ~ $600,000, and the balance of the funds are from USDA RUS and other project partners.

The preferred retrofit strategy for most of the lighting fixtures is to replace the existing magnetic ballasts with high efficiency electronic ballasts and to replace T12 fluorescent lamps with energy efficient T8 lamps. These changes can be readily implemented by facility maintenance personnel and typically take about 10-15 minutes per fixture to complete.

The following table presents the potential electricity savings, electric demand reduction, installation costs, and payback if a Reservation-wide lighting efficiency program were to be implemented in eight of the larger buildings on the Reservation.

Summary Results of Lighting Audits for Major Buildings: Duck Valley Reservation				
	Annual Operating Cost Savings	**Electric Demand Reduction**	**Cost of Retrofits**	**Simple Payback**
8 Buildings (see Appendix A)	$18,500	70+ kW*	$27,000	1.5 Years

* If all lighting fixtures are illuminated at same time (say 3:00PM); actual "coincidental" demand reduction is more likely to be 60+ kW.

Even though the cost of electricity on the Reservation is relatively inexpensive ($0.06/kWh), the payback period for the lighting retrofits is an extremely attractive 1.5 years if the installation labor is provided by existing maintenance personnel. More compelling, however, is an electric load reduction of 60-70 kW that can be achieved, which frees up that amount of load to accommodate other electric load growth between now and 2007 (when the new transmission line and substation is scheduled to be completed).

Recommendations for implementation of these retrofits are found in Section 4.2.

3.0 ASSESSMENT OF SUSTAINABLE DG TECHNOLOGIES (PART 2)

3.1 Part 2 Assessment Tasks

While its primary purpose is to provide an alternate source of electric supply to the Duck Valley Reservation, the new 138 kVa transmission line to be built by RREC in partnership with the Duck Valley Tribes (as described in Section 2.4) has emerged as *the* significant driver in determining which sustainable energy option(s) are most feasible for the Tribes to pursue. Prior to the announcement of the new 138 kVa line, the primary issue was reliability and deliverability (electricity costs are not a high priority, as the area has relatively inexpensive power when the power is flowing), with no prospect for exporting renewable-based electricity off the Reservation. This pre-proposal scenario favored the consideration of small-scale wind, solar photovoltaics, and even propane-fueled fuel cells. With the new transmission line now scheduled for completion by 2007, the emphasis of the *Study* was redirected at evaluating the feasibility of large-scale wind power for use by the Tribes as well as off-Reservation sales. For educational purposes, information about the applicability of solar photovoltaics and fuels cells on the Reservation is also provided in the following sections.

3.2 Wind Power

3.2.1 Overview of Previous Wind Resource Characterizations at Duck Valley

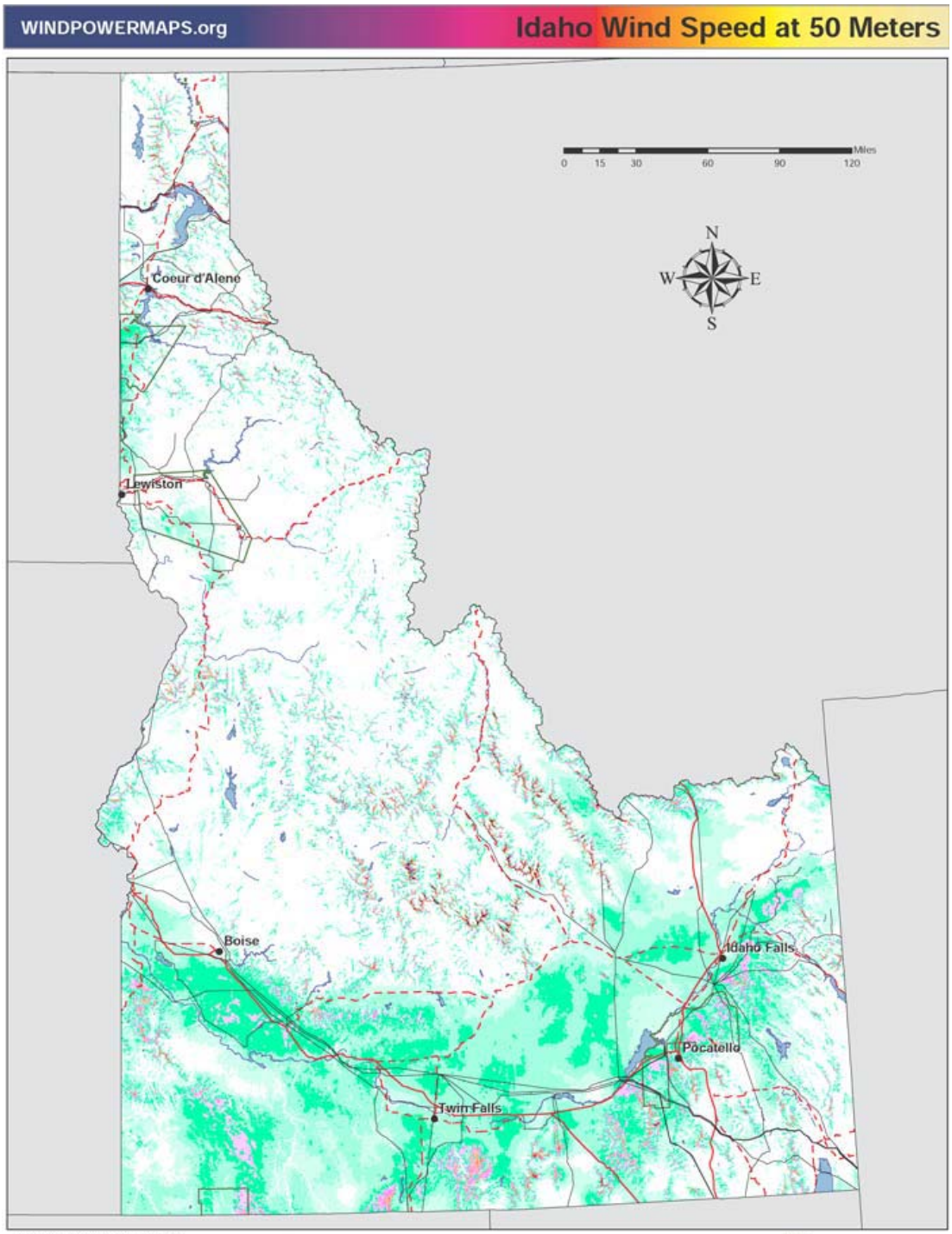
The wind resource for the State of Idaho presented on the following pages (with the Duck Valley Reservation indicated in the far southwest part of the State) indicates that lands along the northern and eastern edges of the Reservation have the highest relative wind speeds on the Reservation and compare favorably with other windy area of Idaho.

To gather site specific on the Duck Valley Reservation, an anemometer was previously installed on the Duck Valley Reservation as part of the NREL Native American Anemometer Loan Program. The initial monitoring site (Site #3246) was located south of the town of Owyhee at 7180 feet. The monitoring period ran from June 2001 to March 2002, with the annual average wind speed at 20 meters measured to be 16.1 mph (or ~ 18.4 mph at 50 meters). This would be considered a Class 6 (rated "Outstanding") wind resource, albeit based on very short term data. Based on these preliminary results, NREL recommended further study of wind resources on the Reservation, suggesting a full-fledged wind monitoring program.

Although the preliminary data collection effort was encouraging, the initial site chosen on the Reservation was not appropriate for wind farm development. It is remote and difficult to access, would not support more than a few wind turbines, and it is situated 10-15 miles away from the Mountain City substation (across very rugged terrain), which is interconnected to a capacity-constrained and failure-prone transmission line.

Based on the constraints for development of the initial site and the announcement of the new transmission line and substation, the emphasis of wind data collection efforts moved to sites located on the northern half of the Reservation. However, for comparative purposes with other data collection sites on and near the Reservation, the NREL anemometer tower and its instruments were reinstalled and are presently collecting data.

Duck Valley Reservation Average Wind Speeds Site #3246 (66 ft. (20m) tower) N. 41.8528 deg., W. 116.124 deg. Elevation – 7180 ft.	
June (6/21/01 – 6/30/01)	14.5 mph
July 2001	13.4 mph
August 2001	13.5 mph
September 2001	13.4 mph
October 2001	17.1 mph
November 2001	18.2 mph
December 2001	18.6 mph
January 2002	16.8 mph
February 2002	17.7 mph
March (3/1/02 – 3/7/02)	19.8 mph
Overall Average (6/21/01 – 3/7/02)	**16.1 mph**
	18.35 mph at 50m



Wind Speed at 50 meters

m/s	mph
0 - 5.0	0 - 11.2
5.0 - 5.5	11.2 - 12.3
5.5 - 6.0	12.3 - 13.4
6.0 - 6.5	13.4 - 14.5
6.5 - 7.0	14.5 - 15.7
7.0 - 7.5	15.7 - 16.8
7.5 - 8.0	16.8 - 17.9
8.0 - 8.5	17.9 - 19.0
8.5 - 9.0	19.0 - 20.1
9.0 - 9.5	20.1 - 21.3
9.5 - 10.0	21.3 - 22.4
>10.0	>22.4

- Major Cities
- Transmission Lines > 115 KW
- Limited Access Highway
- Highway
- Tribal Reservations

Project Sponsors

NREL, the Bonneville Power Administration, Northwestern Energy, the Wyoming Business Council, enXco, the Northwest Power Planning Council, Zilkha Renewable Energy, Klickitat County, EnronWind, ABB, Renewable Energy Systems (USA) Inc., Chelan Public Utility District, Idaho Power, Windland, Inc., WSACAA Energy Project, Vestas, Jones & Stokes, CH2M Hill, Suzlon Energy, Northwest Wildlife Consultants, Inc., and Cielo Wind Power.

The wind resource estimates presented on this map were developed by TrueWind Solutions using MesoMap, a mesoscale atmospheric simulation system, at a spatial grid resolution of 400 meters (one-quarter mile). The estimates have been validated by the National Renewable Energy Laboratory (NREL) and independent meteorologist but should be confirmed by direct measurement according to wind energy industry standards.

For more information see www.windpowermaps.org

3.2.2 Overview of Current Wind Resource Characterizations at Duck Valley

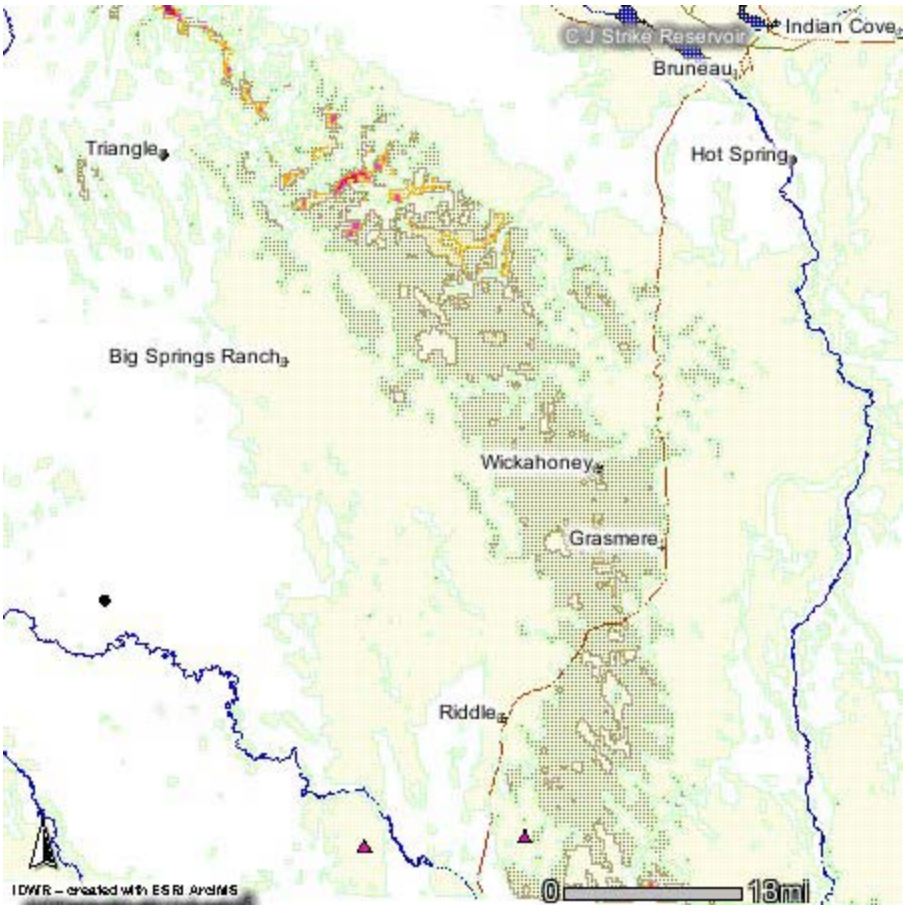
The 138 kVa transmission line to be constructed by RREC will originate at the C J Strike Reservoir near Bruneau, Idaho and continue south along Highway 51 for approximately 56 miles to a substation south of Riddle, Idaho and one mile north of the northern border of the Duck Valley Reservation. This line will be lightly loaded for many years (~ 10%) and provides a "gateway" for exporting wind-generated power to regional markets. The transmission line's proposed route from Bruneau to the Duck Valley Reservation traverses a "banana shaped" expanse of high, well exposed, open range land, much of which is Federal land [either the Bureau of Land Management or the US Air Force (the Mountain Home Air Force Base is north and west of Bruneau)].

The primary objective of the *Study* with regards to wind resource characterization was to gather new wind data on high ground at the northern end on the Reservation where, if wind power were found to be feasible, a wind farm project could be interconnected to the substation to be built at Riddle. In addition to the continuation of data collection on the original Duck Valley/NREL site, two new wind farm sites were scouted and 20 meters towers provided by the Idaho Department of Water Resources (IDWR) were installed, one at the "Miller Creek" site and the other at the "Antelope Springs" site.

Directly south of the proposed substation at Riddle is the Owyhee Valley and the town of Owyhee, where most of the Tribes' population and infrastructure is based. To the southeast of the Riddle substation and directly east of the Tribal Headquarters is the Miller Creek site – high, well exposed treeless land (~ 6400 to 6660 feet) that is a continuation of the area's "banana-shaped" topographic feature. The Miller Creek site is a gradually sloping (up to the south) site, sits about 1000 feet above the Owyhee Valley situated to the west, and could support tens of MWs of wind power. It is presently difficult to reach the site as the area is accessed primarily by 4-wheel drive vehicles, but improved roads could be built from Highway 51. The distance from the Miller Creek site to the proposed substation at Riddle is about 5-6 miles.

On the west side of the Owyhee Valley at 5700 feet elevation (300 to 400 feet above the Owyhee Valley) is the Antelope Springs site. This site also a relatively high, well exposed, treeless location that is dissected by a gravel road that is well maintained by a major pipeline company. The distance from the Antelope Springs site to the proposed substation at Riddle is about 10-12 miles.

In addition to the Miller Creek and Antelope Springs sites, the Idaho Department of Water Resources installed an anemometer on an existing tower at a remote US Air Force communications site at Grasmere, Idaho, which is situated on high exposed ground north of the Owyhee Valley and north of the Duck Valley Reservation. The Grasmere site is situated approximately mid point on the "banana-shaped" topographic feature and is a very useful point of comparison to the two Duck Valley wind data collection sites (designated by the triangles in the map below).



3.2.3 Results of Wind Resource Data Collection at Duck Valley

Data collected from the Idaho Department of Water Resources anemometers was processed by the Idaho National Environmental Engineering Laboratory (INEEL). The following tables present the average monthly winds speeds at 20 meters for the Miller Creek, Antelope Springs, and Grasmere data collection sites for the period October 2003 to September 2004. This data indicates that the Miller Creek and Grasmere sites have comparable annual average wind speeds of 13.8 and 14.1 mph, respectively [which would place both sites in the Class 4 category ('Good" rating)], while the annual average wind speed at Antelope Springs site is considerably less at 11.4 mph [which would place the site in the Class 2 category ("Poor" rating).

"Wind Analysis Summary Reports" provided by INEEL and shown in Appendix B provide prevailing wind direction, power output from a candidate wind turbine, and frequency distribution data for the three sites. The average wind direction for all three sites is from the southwest (Miller Creek: 202 degrees). INEEL estimates that the gross capacity factor for a 65m tall 1.5 MW turbine at the Miller Creek site is 32% (scaled up from 20m assuming average wind shear), while the same turbine would have a slightly better (33-36%) gross capacity factor at the Grasmere site.

The Duck Valley Tribes are continuing to collect and analyze wind resource data for the Miller Creek and Antelope Springs for another 6 months (until approximately June 2005) and has submitted an application to NREL for a 50 meter tower to be placed at the Miller Creek site and operated for at least one additional year.

Duck Valley Miller Creek Average Wind Speeds Site #0131 (66 ft. (20m) tower) **N. 42 deg. 3.728', W. 116 deg. 4.690'** Elevation – 6591 ft.	
October (10/15/03 – 10/31/03)	13.6 mph
November 2003	15.2 mph
December 2003 (2 days of iced data taken out)	16.0 mph
January 2004 (2.5 days of iced data taken out)	13.6 mph
February 2004 (1.5 days of iced data taken out)	14.5 mph
March 2004	14.2 mph
April 2004	12.6 mph
May 2004	13.3 mph
June 2004	13.6 mph
July 2004	12.5 mph
August 2004	13.1 mph
September 2004	12.2 mph
October 2004	13.4 mph
November (11/1/04 – 11/16/04)	11.4 mph
Overall Average (10/15/03 – 10/15/04)	**13.6 mph**
	15.5 mph at 50 m

Duck Valley Antelope Springs Average Wind Speeds Site #0215 (66 ft. (20m) tower) **N. 42 deg. 2.905', W. 116 deg. 18.501'** Elevation – 5727 ft.	
October (10/14/03 – 10/31/03)	11.0 mph
November 2003	12.0 mph
December 2003	13.0 mph
January 2004 (1 day of iced data taken out)	12.7 mph
February 2004	11.7 mph
March 2004	10.9 mph
April 2004	10.7 mph
May 2004	11.4 mph
June 2004	11.3 mph
July 2004	10.2 mph
August 2004	11.1 mph
September 2004	9.9 mph
October 2004	10.3 mph

November (11/1/04 – 11/16/04)	9.0 mph
Overall Average (10/14/03 – 10/14/04)	**11.2 mph**
	12.8 mph at 50 m

Grasmere Station, Mountain Home AFB Average Wind Speeds Site #7001 (70 ft. existing tower) **N. 42 deg. 18', W. 115 deg. 59' (approximate)** Elevation – 5940 ft. (approximate)	
October (10/14/03 – 10/31/03)	14.0 mph
November 2003	15.8 mph
December 2003	16.1 mph
January 2004 (3 days of iced data taken out)	16.1 mph
February 2004 (2.5 days of iced data taken out)	15.1 mph
March 2004	14.1 mph
April 2004	13.1 mph
May 2004	14.1 mph
June 2004	12.0 mph
July 2004	11.1 mph
August (8/1/04 – 8/12/04)	13.2 mph
Overall Average (10/14/03 – 8/12/04)	**14.1 mph**
	16.1 mph at 50 m

3.2.4 Next Steps for Duck Valley Wind Development Efforts

Before efforts to develop its wind resources can be aggressively pursued, the Duck Valley Tribes must "firm up" their wind resource. The one-year wind speed data results from the Miller Creek site are very encouraging, as are the results from the Grasmere site to the north of the Reservation. However, both sites have been instrumented with anemometers at approximately 20m, far below the hub height (60+ meters) of modern, large-scale wind turbines. While extrapolation of wind speeds from 20m to wind turbine hub height is frequently done using rules of thumb (e.g. the 1/7 power law) and is a useful exercise, such extrapolations do not provide sufficient confidence in multi-year wind speeds (and direction) to justify the commitment of significant financial resources to develop a wind farm.

Further, extrapolation rules of thumb for determining wind shear at turbine height (say 60-80 m) may not be appropriate for the Miller Creek site as it sit atop a large mesa-like topographic feature. It is entirely plausible that there is considerable acceleration of wind speed on top of the mesa as southwesterly air flow rises up and over the edge of the land form and forms a "zone of compression" above the mesa. The characteristics (height, thickness, etc.) of this "zone of compression" are not currently understood.

To illustrate the importance of understanding the wind resource at turbine height, wind resource data for the Miller Creek site was used in a preliminary analysis of a 50 MW wind farm using the RETScreen

Wind Energy Model, with the model's output also shown in Appendix B. Annual average wind speeds of 13.8 mph (6.2 m/s) were entered into the model, along with the power output profile from a utility scale wind turbine (1.65 MW) and a wind shear exponent value. Three separate scenarios were run using: 1) wind shear exponent of 0.14 (based on the 1/7 power law), 2) wind shear exponent of 0.20, and 3) wind shear exponent of 0.26.

For each of the three scenarios the model estimated electricity production from a hypothetical wind farm using 30 turbines (accounting for array interaction and other system losses) and plant capacity factor. The RETScreen model was also used to generate an estimate of costs for the hypothetical 50 MW wind farm based on recently built wind farm projects elsewhere and provided the basis for a preliminary financial analysis shown in Appendix B.

The results of the modeling are summarized in the table below.

EFFECT OF WIND SHEAR ASSUMPTIONS ON FEASIBILITY OF 50 MW WIND FARM				
Wind Shear Exponent	**Electricity Delivered (MWh)**	**Wind Plant Capacity Factor**	**Project Cost ($ Million)**	**Pretax IRR and ROI (%)**
0.14	102,635	0.24	47.3	16.6
0.20	118,650	0.27	47.3	21.7
0.26	134,903	0.31	47.3	26.7

This table indicates the importance of understanding more definitively the wind resource at or near the hub height of the turbines to be used in a wind project. If standard rules of thumb are applied (0.14 wind shear exponent yielding a wind speed at hub height of 7.3 m/s), a 50 MW wind farm at the Miller Creek site looks financially attractive given the use of low cost (3%), long term (30 years or more) financing from USDA RUS. The electricity output and financial attractiveness of the 50 MW wind farm project would be even greater if the average wind speed at turbine height were empirically determined by field measurements to be 7.9 m/s (0.20 wind shear exponent).

As part of a proposed Phase II *Duck Valley Wind Farm Project Feasibility Study*, the Duck Valley Tribes will seek additional funding from the DOE Tribal Energy Program to:

1) install one or more 50 meter anemometer towers at the Miller Creek and Grasmere sites to collect wind resource data at heights that are better matched with utility-scale wind turbines; and

2) deploy SODAR equipment to collect shorter term data (in conjunction with the longer term data from the taller towers) to better characterize vertical wind shear at multiple data points on the prospective wind farm sites.

Given the timing of the completion of the RREC transmission line and substation in 2007, Duck Valley will use the period from 2005 to 2007 to conduct this additional round of wind resource data collection so that wind farm development, if proven to be feasible, can proceed in the 2007/2008 timeframe.

3.3 Solar Power

Photovoltaic modules (also called panels) convert direct sunlight to direct current electricity. There are two basic types of photovoltaic (PV) cells: crystalline silicon and thin film. PV modules typically have a peak power output of 50 to 300 watts. Modules can be assembled into arrays, which can vary from just two modules for a small residential system to hundreds of modules for a utility-scale system of 100 kW or more. The PV modules are the fundamental, but not the only, components of a PV system. Various

mounting brackets, supports, and hardware are required to position and hold the modules. An inverter is required to convert the modules' direct current (DC) output to the grid's alternating current (AC) standard. A step-up transformer may be required to increase the voltage to that of the grid. The costs of these non-module, or balance of system (BOS), components are significant. They make up almost half of total system costs.

At the benchmark retail price of $7,000 to $10,000 per kilowatt, PV systems yield electricity at a cost of 25 to 40 cents per kilowatt-hour, roughly four to six times the typical price a grid connected Duck Valley residential customer pays for power. However, PV system can become immediately competitive where utility lines are not available. Packaged PV systems for remote applications rated at 1 to 2 kW may cost $10,000 to $20,000, which is far less than the cost to extend the electric grid ($25,000+ per mile). PV systems can benefit from economies of scale for larger projects. Costs per kilowatt can be significantly reduced for systems in the 10+ kW range (approximately $5-7 per Wp) compared to the smaller 1-2 kW systems ($10/Wp or more).

As the Duck Valley Reservation is situated in a high, semi-arid location, it has a relatively high average solar radiation resource of 5.5-6.0 kWh/m2/day (flat plate, facing south, latitude tilt). The use of solar photovoltaic systems is primarily an electric supply option for electric loads (e.g. irrigation pumping, communication equipment, etc.) that are a mile or more off the existing distribution system. A prime example of the use of PV systems in the area is the 75 kWp PV-diesel hybrid system that provides power to the off-grid US Air Force communication facility at Grasmere.

While the distribution system serving the Reservation is now capacity constrained and relatively unreliable and PV systems could be used to meet (or partially meet) individual on-grid loads or support the local distribution network, use of on-grid PV systems at Duck Valley are not expected to be cost competitive in the near future as the development of the new transmission line and substation serving the Reservation is scheduled for 2007 and the region has one of the lowest costs of electricity in the country ($0.06/kWh).

3.4 Fuel Cells

Fuel cells are an emerging energy technology that may be a cost effective distributed generation option within 5 to 10 years. Fuel cells are electro-chemical devices that convert a hydrogen based fuel (such as propane or natural gas) into electricity with virtually no emissions other than heat and water vapor. Even the waste heat might be utilized for water heating or space heating. Fuel cells are being developed by a growing number of North American companies in sizes for individual homes, automobiles (to replace the internal combustion engine with an electrical power source for electric vehicles), medium to large scale commercial facilities, and smaller central plant generating stations.

The most likely near term applications for fuel cell applications on the Duck Valley Reservation would be building-sited systems that would be fueled by propane. The system economics of fuel cell/propane systems would need to be compared to that of grid power, micro-turbine/propane systems, PV systems, and utility-scale wind systems, but it is believed that once fuel cells production ramps up in the next decade, fuel cells could represent a viable power option for the Duck Valley Reservation.

Fuel cells also may have a future relationship to wind farm developments that may be pursued by the Duck Valley Tribes. There is considerable interest among energy planners in using electricity generated from wind farms to produce hydrogen gas (via electrolysis of water). It is conceivable that electricity from a Duck Valley wind farm could be sold to off-reservation markets via the new transmission line, with some portion of the electricity being devoted to a local electrolyis facility that would "manufacture" hydrogen for use with fuel cells on the Reservation.

4.0 SUMMARY OF BENEFITS/BARRIERS AND IMPLEMENTATION REQUIREMENTS

The primary objective of *A Feasibility Study of Sustainable Distributed Generation Technologies to Improve the Electric System on the Duck Valley Reservation* was to address the reliability and deliverability of the electric distribution system on the Reservation so that economic development initiatives can continue to be pursued. Secondary objectives of the *Study* that also are supportive of economic development included:

- a reduction in energy-related expenditures by Tribal businesses and households;
- creation of energy-related jobs on the Reservation; and
- preservation of the environment on the Reservation.

4.1 Benefits and Barriers

The economic benefits that can result from deploying DG technologies assessed in the *Study* include:

- the distribution system capacity (60+ kW) that is "freed up" by lighting efficiency upgrades alone, enabling other loads (i.e. new economic development initiatives) to be accommodated;
- the operating cost savings for electrical end users; and
- the local jobs created to install, operate, and maintain DG systems, particularly if a large scale wind farm project is built.

There *are* barriers to DG technology deployment at Duck Valley that will need to be addressed. First, DG technologies in general may be perceived as a threat to the local electric provider, RREC. However, in the situation at Duck Valley where RREC has been unable to accommodate additional load growth on the Reservation without major system upgrades, RREC will likely view the use of energy efficiency and DG technologies as a strategy to meet its obligation to provide reliable electric service to Duck Valley in a cost effective and environmentally-sensitive manner. Further, since RREC is the primary partner in the new 138 kVa line that will serve the Reservation by 2007, RREC may be extremely motivated to support the development of a wind farm project in partnership with the Duck Valley Tribes in order to amortize an otherwise lightly loaded transmission line.

A second barrier to DG technology deployment at Duck Valley is the region's low cost of electricity. The cost of electricity to current end users on the Reservation is well below the national average, due in large part to region's hydropower generation. Justifying small scale DG technologies on the Duck Valley Reservation based on electricity (kWh) savings alone will be difficult. However, as there is upward pressure on electricity costs in the Pacific Northwest and elsewhere, large-scale wind projects using above average wind resources (such as those found at Duck Valley) can be competitive with grid power when Federal, state, and buyer (i.e. green tags) production incentives are considered.

4.2 Required Steps for Project Implementation

The required steps for pursuing the implementation of the two primary energy initiatives that have emerged as a result of this *Study* are:

<u>*Duck Valley Wind Farm Project*</u>

Step 1. Apply for Phase II Funding (2 Years) from the 2005 DOE Tribal Energy Program for the following activities:

- Installation of one to two 50m anemometer tower at the Miller Creek site on the Reservation;

- ❑ Deployment of SODAR on a short term basis (6 months) to supplement (i.e. vertical wind shear profiles) the fixed 50m tower data at multiple data points across the wind farm sites;
- ❑ Conduct environmental (including avian study) and cultural assessments of Miller Creek site;
- ❑ Conduct preliminary design of a wind farm project (50 MW or higher) on the preferred local site, including turbine layout and transmission interconnection;
- ❑ Prepare detailed energy production and cost estimates for the wind farm project; and
- ❑ Perform financial modeling based on prevailing loan rates, production incentives, and other factors.

Step 2. Meet with BLM and USAF Regarding Access/Restrictions to Lands North of the Reservation

Step 3. Meet with RREC and Other Partners Re: Access to 138kV Line for Export Use

Step 4. Meet with USAF and Other Regional Electricity Users Re: Power Purchase Interest

Step 5. Review Funding/Financing Sources:

- ❑ the States of Nevada and/or Idaho;
- ❑ USDA [economic development programs, Rural Utility Service (which makes low cost, long term loans available for rural electric organizations)];
- ❑ Departments of Commerce and HUD (rural economic development programs, community development block grants, etc.)
- ❑ Department of Energy (from "project development" funds available from subsequent *Renewable Energy Development on Tribal Lands* solicitations)

Step 6. Meet w/ Potential Project Development Partners (if required)

Step 7. Complete the Activities from the DOE Phase II Study (see Step 1)

If DOE funding is made available in a timely manner by late 2005, these steps can be accomplished between 2005 and 2007, with construction start-up of a wind farm project possible in late 2007 or 2008.

Duck Valley Re-Lighting Project

The economics of the proposed relighting strategies are compelling enough for most of the buildings audited that immediate, economically justified action could be taken by the managing entities (i.e. Duck Valley Tribal Government, Owyhee School, IHS, etc.). A *Duck Valley Re-Lighting Project* could also be pursued in a collaborative manner among the various managing entities so that lighting equipment is purchased, at least initially, in bulk (i.e. electronic ballasts and T8 lamps) and facility maintenance personnel can share information on installation strategies and procedures.

Step 1. Explore Interest from RREC and States of Idaho/Nevada in Project

Step 2. Present Information to Building/Program Managers and Facility Maintenance Personnel

If Consensus is to Pursue Retrofits Individually

Step 3. Commence Retrofits

If Consensus is to Pursue Retrofits Collaboratively

Step 3. Seek Funding Support (e.g. HUD RHED Program or BPA/NW SEED Programs)

Step 4. Buy Equipment in Bulk

Step 5. Commence Retrofits

APPENDIX A LIGHTING INVENTORY DATA FOR DUCK VALLEY BUILDINGS

Lighting System Inventory for Major Buildings on Duck Valley Indian Reservation

Hospital

All fluorescent lighting systems operate at 277V.

Typical lamp/ballast is F40T12CW lamp (some F34T12CW) with V2S40TP Advance magnetic ballast.
U-bend lamp is F40CW-U-6 super cool white
8' T12 lamps only used in shop (F96T12CWWM (single pin)

Backup diesel generator rated at 350 kW max (8-10 system outages/year; 1 hour average outage)
30,000 gallon propane tank (~$0.46/gallon in bulk)

Hallways/Outpatient Waiting

42 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps
(~15 more 2x2 fixtures are permanently disconnected because there was too much light in the hallways)

1 2x4 4 lamp recessed fixture with T12 lamps over the receptionist work area

Dental Clinic (Room 6)

12 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps (bright but appropriate)

Room 4 (locked)

Pharmacy

10 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps (bright but appropriate)

Pharmacist Office

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Men's Restroom (at top of stairs)

1 4"x4' 2 lamp fixture with T12 CW lamps

1 4"x2' 2 lamp fixture with T12 CW lamps (above mirror)

Women's Restroom (at top of stairs)

1 4"x4' 2 lamp fixture with T12 CW lamps

1 4"x2' 2 lamp fixture with T12 CW lamps (above mirror)

Room 87 Suite

14 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

1 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Laboratory

15 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Lab Hallway

8 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Blood Bank (Room 80)

4 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Radiology (Room 70)

14 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Room 60)

4 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Emergency Hallway

6 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Emergency Surgery (Room 175)

10 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Housekeeping (Room 64)

9 18”x4’ 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Linen

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Room 77

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

2 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Supply (Room 173)

20 18”x4’ 2 lamp suspended fixtures with T12 CW lamps

EMT Storage

6 18”x4’ 2 lamp suspended fixtures with T12 CW lamps

EMT Vestibule

1 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Mechanical

15 6”x4’ 2 lamp suspended channel fixtures with T12 CW lamps

Staff Lounge/Cafeteria

4 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps (w/ 4 others disconnected)

Kitchen

21 12”x4’ 2 lamp surface mounted fixtures with acrylic lens and T12 CW lamps

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

2 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

2 2x2 2 lamp surface mounted fixtures with acrylic lens with U-bend T12 CW lamps

Men’s Restroom

2 4”x4’ 2 lamp fixture with T12 CW lamps

1 4”x2’ 2 lamp fixture with T12 CW lamps (above mirror)

Women’s Restroom

1 4”x4’ 2 lamp fixture with T12 CW lamps

1 4”x2’ 2 lamp fixture with T12 CW lamps (above mirror)

Optometrist

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Optometrist Hallway/Reception

5 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

3 1x4 2 lamp surface mounted fixtures with T12 CW lamps

Optometrist Waiting

4 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Conference Room (behind optometrist waiting room)

10 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps
[too much light (used to be a birthing room); 4 lamp ballast w/ 2 lamps is recommended]

Counselor Room/Storage Room

4 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Patient Room (Typical; 12 in total)

2 6”x4’ 2 lamp wall mounted fixtures with T12 CW lamps

1 6”x2’ 2 lamp wall mounted fixture with T12 CW lamps

Medical Staff Counter

8 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Nurse’s Locker Room

2 1x4 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

1 6”x2’ 2 lamp wall mounted fixture with T12 CW lamps (above mirror)

Nurses Office

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

1 6”x4’ 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

Nourishment (Room 127)

1 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Linen (soiled)

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Staff Locker

1 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Storage (Rooms 129 and 132)

6 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Tub Room

1 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Dental Office

6 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Health Information/Records (Room 46)

12 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Behavioral Health (Room 16)

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

1 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Conference Room (Room 34)

6 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Mental Health (Room 20)

8 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Substance Abuse (Room 33)

3 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Office (Room 22)

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Office (Room 23)
2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Office (Room 27)

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Office (Room 29)

1 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Storage (Room 31)

1 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Soiled Utility (Room 32)

1 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Exam Rooms (4 in total)

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Allergy

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Inpatient Nursing System

4 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

7 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Waiting Room Office

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Maintenance Shop (lower level)

8 18”x8’ suspended fixtures with F96T12 lamps

Hallway (lower level)

14 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Workout Room (lower level)

10 6”x4’ 2 lamp fixtures with clear lens with T12 CW lamps

West Entry Vestibule (lower level)

1 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Men’s Restroom

5 1x4 2 lamp surface mounted fixture with T12 CW lamps

Women’s Restroom

5 1x4 2 lamp surface mounted fixture with T12 CW lamps

Bottom of Stairs (lower level)

1 2x2 2 lamp recessed fixtures with acrylic lens with U-bend T12 CW lamps

Rooms 18, 20, 21, 22, 23, 24, 25, 26, 27 (lower level)

34 2x4 3 lamp recessed fixtures with acrylic lens with T12 CW lamps

Room 109 (lower level)

8 2x4 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Storage – Room 109 (lower level)

12 18”x4’ 2 lamp suspended fixtures with T12 CW lamps

Total

4 foot fixtures
4 lamp: 176
3 lamp: 34
2 lamp: 164

2 foot fixtures (u-bends)
2 lamp: 76

8 foot fixtures
2 lamp: 8

Tribal Headquarters

Exterior-West Entry

6 12”x12” medium base incandescent fixture (60-75W lamps) (on 24 hours per day!)
(fixture will easily accommodate a screw-in CFL of 18-20W)
(fixture lens need to be removed and washed)

Lobby

17 12”x12” medium base incandescent fixture (60-75W lamps)

Council Chambers

23 12”x12” medium base incandescent fixtures (60-75W lamps)

4 pedestal mounted open fixtures with very large incandescent bulb (~300W with large base)
(use a high wattage CFL with large base or use new “low bay” metal halide fixtures)

Hallway (north-south)

25 12”x12” medium base incandescent fixtures (60-75W lamps)

Hallway-Copy

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps (some F40CW, some F34CW)

4 2x2 2 lamp fixtures with acrylic lens with U-bend CW lamps

South Offices

25 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

South Entrance

2 12”x12” medium base incandescent fixtures (60-75W lamps)

Men’s Restroom

1 12”x12” medium base incandescent fixture (60-75W lamps)

2 1x4 2 lamp wall mounted fixtures above mirrors (needs new fixtures w/ acrylic lens)

Women’s Restroom

1 12”x12” medium base incandescent fixture (60-75W lamps)

2 1x4 2 lamp wall mounted fixtures above mirrors (needs new fixtures w/ acrylic lens)

Business Council

4 2x2 2 lamp fixtures with acrylic lens with U-bend CW lamps

Chairman’s Office

4 6”x4’ 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Business Council Conference Room

12 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Reception

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Men’s Restroom (north end)

2 1x4 2 lamp wall mounted fixtures above mirrors (needs new fixtures w/ acrylic lens)

Women's Restroom (north end)

2 1x4 2 lamp wall mounted fixtures above mirrors (needs new fixtures w/ acrylic lens)

North Office

2 2 lamp 6" surface mounted fixture with no lens (nneds new 2 lamp 6" wrap fixture with acrylic lens)

East Offices

26 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

East Office Hall

4 2x2 2 lamp fixtures with acrylic lens with U-bend CW lamps

Basement

22 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Modular Building (East)

26 2x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

3 6"x4' 2 lamp wall mount fixtures with acrylic lens with T12 CW lamps (hallways)

Modular Building (West)

New 2 lamp recessed fixtures with 12 cell egg crate aluminum lens with Philips F32T8TO735 lamps (no retrofit)

Total

60-75W Incandescent Fixtures: 75

4 foot fixtures
4 lamp: 89
2 lamp: 43

2 foot fixtures (u-bends)
2 lamp: 12

Housing Office

West Office

5 2x4 3 lamp recessed fixtures with acrylic lens with T12 CW lamps

Conference Room

6 2x4 3 lamp recessed fixtures with acrylic lens with T12 CW lamps

Hallway

6 1x4 2 lamp recessed fixtures with acrylic lens with T12 CW lamps

Directors Office

2 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Office

1 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Finance

1 2x4 4 lamp recessed fixtures with acrylic lens with T12 CW lamps

Kitchen

1 2x4 3 lamp recessed fixtures with acrylic lens with T12 CW lamps

East Offices

6 2x4 3 lamp recessed fixtures with acrylic lens with T12 CW lamps

Shop

18 6”x4’ 2 lamp channel fixtures with open cage screen and F40T12 CW lamps

Laundry

13 2x4 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

4 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

2 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (bathroom)

Total

4 foot fixtures
4 lamp: 17
3 lamp: 18
2 lamp: 30

Wildlife & Parks

Entry & Offices

20 2x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Tool Room

3 1x4 3 lamp surface mounted C fixtures (open) with T12 CW lamps

Shop

4 high bay mercury vapor fixtures (no retrofit; bay door is usually open and shop not used in winter)

Food Distribution

Office

4 1x4 2 lamp surface mounted (double check this) fixtures with acrylic lens with T12 CW lamps (best to use new 2 lamp fixtures with T8 841 lamps and electronic ballasts)

Warehouse
17 18”x8’ 2 lamp suspended fixtures with C reflector and F96T12CW lamps (single pin)

Human Development Center (HDC)

Hallway/Foyer

10 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Kitchen/Storage

4 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Office

1 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Meeting

8 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Recreation Office

3 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Curriculum Office

3 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Economic Development

6 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Women’s Restroom

3 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

1 18”x4’ 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

Men’s Restroom

3 18”x4’ 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

1 18”x4’ 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

Meeting Room

23 18”x4’ 4 lamp surface mounted fixture with acrylic lens with T12 CW lamps

Gym

24 metal halide fixtures (~250 W)…no retrofit

Weight Room

6 18”x4’ 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps (some missing lens)

Total

4 foot fixtures
4 lamp: 64
2 lamp: 8

Resource Center

Hallway-West End

9 6”x4’ 1 lamp surface mounted fixtures (7 mounted end to end & 2 mounted separate) w/ old yellow thick plastic lens
(retrofit with new 1 lamp wrap fixture with acrylic lens with T8 841 lamp and electronic ballast)

Newspaper

4 18”x4’ 4 lamp surface mounted fixture with acrylic lens with T12 CW lamps (poor condition)
(retrofit w/ new 18”x4’ 3 lamp surface mounted wrap fixture w/ acrylic lens w/ T8 lamps and electronic ballast)

Men’s Restroom

1 4”x4’ 2 lamp channel surface mounted fixture with no lens
(retrofit w/ new 2 lamp wrap around surface mounted fixture with acrylic lens (~6” wide))

Women’s Restroom

1 4”x4’ 2 lamp channel surface mounted fixture with no lens
(retrofit w/ new 2 lamp wrap around surface mounted fixture with acrylic lens (~6” wide))

Front Reception Office

2 18”x4’ 4 lamp surface mounted fixture with acrylic lens with T12 CW lamps (poor condition)
(retrofit w/ new 18”x4’ 3 lamp surface mounted wrap fixture w/ acrylic lens w/ T8 lamps and electronic ballast)

South Office

2 18”x4’ 4 lamp surface mounted fixture with acrylic lens with T12 CW lamps (poor condition)
(retrofit w/ new 18”x4’ 3 lamp surface mounted wrap fixture w/ acrylic lens w/ T8 lamps and electronic ballast)

South Office

4 18”x4’ 4 lamp surface mounted fixture with acrylic lens with T12 CW lamps (poor condition)
(retrofit w/ new 18”x4’ 3 lamp surface mounted wrap fixture w/ acrylic lens w/ T8 lamps and electronic ballast)

SE Office

4 18”x4’ 4 lamp surface mounted fixture with acrylic lens with T12 CW lamps (poor condition)
(retrofit w/ new 18”x4’ 3 lamp surface mounted wrap fixture w/ acrylic lens w/ T8 lamps and electronic ballast)

Hallway (East End)

9 6”x4’ 1 lamp surface mounted fixtures (7 end to end with 2 separate) with old yellow thick plastic lens
(retrofit with new 1 lamp wrap fixture with acrylic lens with T8 841 lamp and electronic ballast)

North Offices

18 2x4 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps
(older fixtures in OK condition, but may be retrofitted w/ new 3 lamp fixtures to be consistent w/ other new fixtures)

South Offices

10 2x4 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps
(older fixtures in OK condition, but may be retrofitted w/ new 3 lamp fixtures to be consistent w/ other new fixtures)

Total

4 foot fixtures (all new fixtures)
4 lamp: 44
2 lamp: 2
1 lamp: 18

Senior Center/Daycare

Daycare

26 18’x4’ 4 lamp surface mounted fixtures with wrap acrylic lens and T12 Cw lamps (good condition)

Hallway

4 6”x4’ 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Daycare Coordinators Office

2 18’x4’ 4 lamp surface mounted fixtures with wrap acrylic lens and T12 Cw lamps (good condition)

Senior Center Offices

4 18’x4’ 4 lamp surface mounted fixtures with wrap acrylic lens and T12 Cw lamps (good condition)

Kitchen

3 1x4 2 lamp surface mounted fixtures with wraparound acrylic lens with T12 CW lamps

Meeting Room/Offices

14 18’x4’ 4 lamp surface mounted fixtures with wrap acrylic lens and T12 Cw lamps (good condition)

Total

4 foot fixtures
4 lamp: 46
2 lamp: 7

Owyhee School

T8 lamps (F032/741) and electronic ballasts are presently used in the hallways of the main school building, not in classrooms or hallways of other school buildings.

Typical 4 foot T12 lamps are F40CWSS; typical 8 foot lamps are F96T12CW 75W (single pin); some 14" T12 lamps are F14T12-D (14 watts); 500W incandescent lamps used in gym.

Main Building

Hallways/Foyers

No retrofit….2 lamp fixtures (30 in total) already use T8 lamps and electronic ballasts

Computer

18 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Home Economics

22 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Science

8 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Band Room

12 metal halide fixtures with 250W or 400W MH lamps

2 1x4 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

Shop Meeting Room

4 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Shop

14 pendant mounted mercury vapor fixtures with 175W lamps (no retrofit)

Art Room

8 metal halide fixtures with 250W or 400W MH lamps (no retrofit)

SW Offices

7 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mrs Dick Classroom -3

2 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Secretary

4 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mr. Miller Classroom

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Computer Lab

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mrs. Olson – 8

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Library

11 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Therapist

1 1x4 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

5 surface mounted round incandescent fixtures with 2 bulbs

Mrs. Holmes – 10

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Ms. Rhoden – 12

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Staff Room

4 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Dean

2 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Custodian/Stairs

1 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)

2 surface mounted round incandescent fixtures with 2 bulbs

Ms. Labesky – 19

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Boys Restroom

2 surface mounted round incandescent fixtures with 2 bulbs

Girls Restroom

2 surface mounted round incandescent fixtures with 2 bulbs

Computer Lab -18

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mrs. Lewis -13

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mrs. Woods – 14

6 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mrs. Bieroth -17

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Mrs. Thomas – 15

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Ms. Manning – 16

8 1x4 2 lamp pendant mounted fixtures with acrylic lens with T12 CW lamps (good condition)

Gym

North Foyer and Hallway

13 2x4 2 lamp fixtures with acrylic lens and T12 CW lamps

Kitchen

8 6”x8’ 2 lamp fixtures with clear lens and T12 CW lamps

2 6”x4’ 2 lamp fixtures with clear lens and T12 CW lamps

Gym

64 high wattage (500W) incandescent fixtures
(retrofit with 250W high bay metal halide fixtures….proper count and spacing must be analyzed)

Boys Locker

16 6”x4’ 2 lamp fixtures with clear lens with T12 CW lamps

2 6”x4’ 1 lamp fixtures with no lens with T12 CW lamps

Girls Locker

12 6”x4’ 2 lamp fixtures with clear lens with T12 CW lamps

Boys Restroom

1 1x4 2 lamp wall mount fixture with T12 CW lamps

2 1x4 2 lamp surface mount (with lens missing)

1 1x3 2 lamp fixture with T12 CW lamps

Girls Restroom

1 1x4 2 lamp wall mount fixture with T12 CW lamps

2 1x4 2 lamp surface mount (with lens missing)

1 1x3 2 lamp fixture with T12 CW lamps

Gym Classroom

48 (8 rows of 6) 1x4 2 lamp pendant mounted fixtures w/ acrylic lens with T12 CW lamps (many fixtures missing lens)

Vo-Tech Building

Boys Restroom

1 6”x4’ 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

1 6”x4’ 2 lamp wall mounted fixture (above mirror) with acrylic lens with T12 CW lamps

Girls Restroom

1 6”x4’ 2 lamp surface mounted fixture with acrylic lens with T12 CW lamps

1 6”x4’ 2 lamp wall mounted fixture (above mirror) with acrylic lens with T12 CW lamps

Classroom

15 2x4 4 lamp surface mounted fixtures with acrylic lens with T12 CW lamps (good condition)
(room is very bright…~ 105 footcandles…retrofit with 4 lamp ballasts but delamp to 2 or 3 lamps)

Auto Shop

28 metal halide fixtures with 250W MH lamps (no retrofit)

Hallway

3 1x4 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Other School Buildings

Garage-Bus Bay

11 metal halide fixtures with 250W MH lamps (no retrofit)

Modular – Southwest

28 6”x4’ 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Modular Building (North)

28 6”x4’ 2 lamp surface mounted fixtures with acrylic lens with T12 CW lamps

Total

4 foot fixtures
4 lamp: 15
2 lamp: 350
1 lamp: 2

Owyhee Café

15 2x4 4 lamp surface mounted fixtures with T12 lamps (some fixtures not working, some w/ no lens)
(retrofit w/ new 2x4 3 lamp surface mounted fixtures w/ wraparound lens w/ T8 841 lamps and electronic ballasts)

Other Major Buildings

Juvenile Center – New building with efficient lighting
Fire Station – New building with efficient lighting
Prison – BIA facility; high security and advance permission was not obtained for audit period
Tribal Court – Older, smaller building with real hodge podge of lighting fixtures…low priority

SUMMARY RESULTS OF LIGHTING AUDITS FOR MAJOR BUILDINGS ON DUCK VALLEY RESERVATION

Owyhee Hospital

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	176	192	197345.3	11841	98	100728.3	6044	5797	2992	1584	4576	0	0	4576	0.8
4' 2 lamp	B	164	96	91944.96	5517	51	48845.76	2931	2586	2296	738	3034	0	0	3034	1.2
8' 2 lamp	C	8	158	7381.76	443	110	5139.2	308	135	200	112	312	0	0	312	2.3
4' 3 lamp	D	34	144	28592.64	1716	75	14892	894	822	544	229.5	774	0	0	774	0.9
U 2 lamp	E	76	96	42608.64	2557	51	22635.84	1358	1198	1064	912	1976	0	0	1976	1.6
									10538			10671.5	0	0	10671.5	1.0

Tribal Headquarters

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	89	192	49896.96	2994	98	25468.24	1528	1466	1513	801	2314	0	0	2314	1.6
4' 2 lamp	B	43	96	12053.76	723	51	6403.56	384	339	602	193.5	796	0	0	796	2.3
U 2 lamp	E	12	96	3363.84	202	51	1787.04	107	95	192	144	336	0	0	336	3.6
60-75W Incan	F	75	75	16425	986	18	3942	237	749	0	375	375	0	0	375	0.5
									1899			3821	0	0	3820.5	2.0

Housing Office

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	17	192	9530.88	572	98	4864.72	292	280	289	153	442	0	0	442	1.6
4' 2 lamp	B	30	96	8409.6	505	51	4467.6	268	237	420	135	555	0	0	555	2.3
4' 3 lamp	D	18	144	7568.64	454	75	3942	237	218	288	121.5	410	0	0	410	1.9
									734			1406.5	0	0	1406.5	1.9

Wildlife & Parks

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 2 lamp	B	20	96	5606.4	336	51	2978.4	179	158	280	90	370	0	0	370	2.3
4' 3 lamp	D	3	144	1261.44	76	75	657	39	36	48	20.25	68	0	0	68	1.9
									194			438.25	0	0	438.25	2.3

Food Distribution

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 2 lamp	B	4	96	1121.28	67	51	595.68	36	32	56	18	74	0	0	74	2.3
8' 2 lamp	C	17	158	7843.12	471	110	5460.4	328	143	425	238	663	0	0	663	4.6
									174			737	0	0	737	4.2

Human Development Center

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	64	192	35880.96	2153	98	18314.24	1099	1054	1088	576	1664	0	0	1664	1.6
4' 2 lamp	B	8	96	2242.56	135	51	1191.36	71	63	112	36	148	0	0	148	2.3
									1117			1812	0	0	1812	1.6

Resource Center

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	44	192	24668.16	1480	98	12591.04	755	725	New	New	New	0	0	NA	NA
4' 2 lamp	B	2	96	560.64	34	51	297.84	18	16	New	New	New	0	0	NA	NA
4' 1 lamp	G	18	50	2628	158	28	1471.68	88	69	New	New	New	0	0	NA	NA
									810			NA	0	0	NA	NA

Senior Center/Daycare

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	46	192	25789.44	1547	98	13163.36	790	758	782	414	1196	0	0	1196	1.6
4' 2 lamp	B	7	96	1962.24	118	51	1042.44	63	55	98	31.5	130	0	0	130	2.3
									813			1325.5	0	0	1325.5	1.6

Owyhee School

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	15	192	8409.6	505	98	4292.4	258	247	255	135	390	0	0	390	1.6
4' 2 lamp	B	350	96	98112	5887	51	52122	3127	2759	4900	1575	6475	0	0	6475	2.3
4' 1 lamp	G	2	50	292	18	28	163.52	10	8	28	4.5	33	0	0	33	4.2
									3014			6897.5	0	0	6897.5	2.3

Owyhee Café

	Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
4' 4 lamp	A	15	192	10512	631	98	5365.5	322	309	New	New	New	0	0	NA	NA
									309			NA	0	0	NA	NA

Annual Operating Cost Savings: All Buildings (except Resource Center and Owyhee Café w/ New Fixtures)

Fixture Type	Fixture Count	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Fixture Power (W)	Annual Energy (kWh)	Annual Cost ($)	Annual Savings ($)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
								18484						27109	1.5

Electric Demand Reduction: All Buildings (except Resource Center and Owyhee Café w/ New Fixtures)

Fixture Type	Fixture Count	Existing Power (W)	Annual Energy (kWh)	Annual Cost ($)	Retrofit Power (W)	Annual Energy (kWh)	Annual Cost ($)	Demand Reduction (kW)	Cost of Retrofit Ballast ($)	Lamps ($)	Total ($)	Program Rebate ($)	Utility Rebate ($)	Net Cost ($)	Simple Payback (Yr)
		164283			90081			74.202							

	Existing Fixture Types	Retrofit Recommendation
Fixture Type A:	4 foot 4 lamp fluorescent fixture, magnetic ballast, and 4 foot T12 lamps	Use a 4 lamp electronic ballast w/ 4 T8 lamps (Sylvania QT4x32LP ballast and F032/841/XP/ECO lamps) - Delamp as necessary
Fixture Type B:	4 foot 2 lamp fluorescent fixture with 2 T12 lamps and magnetic ballast	Use a 3 lamp electronic ballast w/ 3 T8 lamps (Sylvania QT3x32LP ballast and F032/841/XP/ECO lamps) - Delamp as necessary
Fixture Type C:	8 foot 2 lamp fluorescent fixture w/ mag. ballast & F96T12CW 60W lamps	Use 2 F096/841/XP/ECO lamps and 1 QT2x59IS electronic ballast
Fixture Type D:	4 foot 3 lamp fluorescent fixture, magnetic ballast, and 4 foot T12 lamps	Use a 3 lamp electronic ballast w/ 3 T8 lamps (Sylvania QT3x32LP ballast and F032/841/XP/ECO lamps) - Delamp as necessary
Fixture Type E:	2x2 2 lamp U-bend fluorescent fixture, magnetic ballast, and U-bend lamps	Use 2 F032U/841/XP/ECO U-bend lamps and 1 QT2x32LP electronic ballast
Fixture Type F:	60-75W incandescent fixture	Use screw-in compact fluorescent lamp (CFL) ~ 18W
Fixture Type G:	4 foot 1 lamp fluorescent fixture w/ magnetic ballast	Use a 1 lamp electronic ballast w/ 1 T8 lamp (QT1x32T8IS ballast and F032/841/XP/ECO lamp)

Assumptions:

1) Electric Rate: $0.06/kWh

2) No labor costs are included in retrofit cost totals; electrician/technician labor is assumed to be conducted by current facility maintenance staff

3) Hours of Operation:

Owyhee Hospital: 16 average hours per day per fixture (some are lit 8-10 hours, others lit 24 hours)

Tribal Headquarters: 8 average hours per day

Housing Office: 8 average hours per day

Wildlife & Parks: 8 average hours per day

Food Distribution: 8 average hours per day

Human Development Center: 8 average hours per day

Resource Center: 8 average hours per day

Senior Center/Daycare: 8 average hour per day

Owyhee School: 8 average hours per day (during school year hours are higher; during summer hours are lower)

Owyhee Café: 10 average hours per day

APPENDIX B
WIND ANALYSIS SUMMARY REPORTS
(MILLER CREEK SITE)

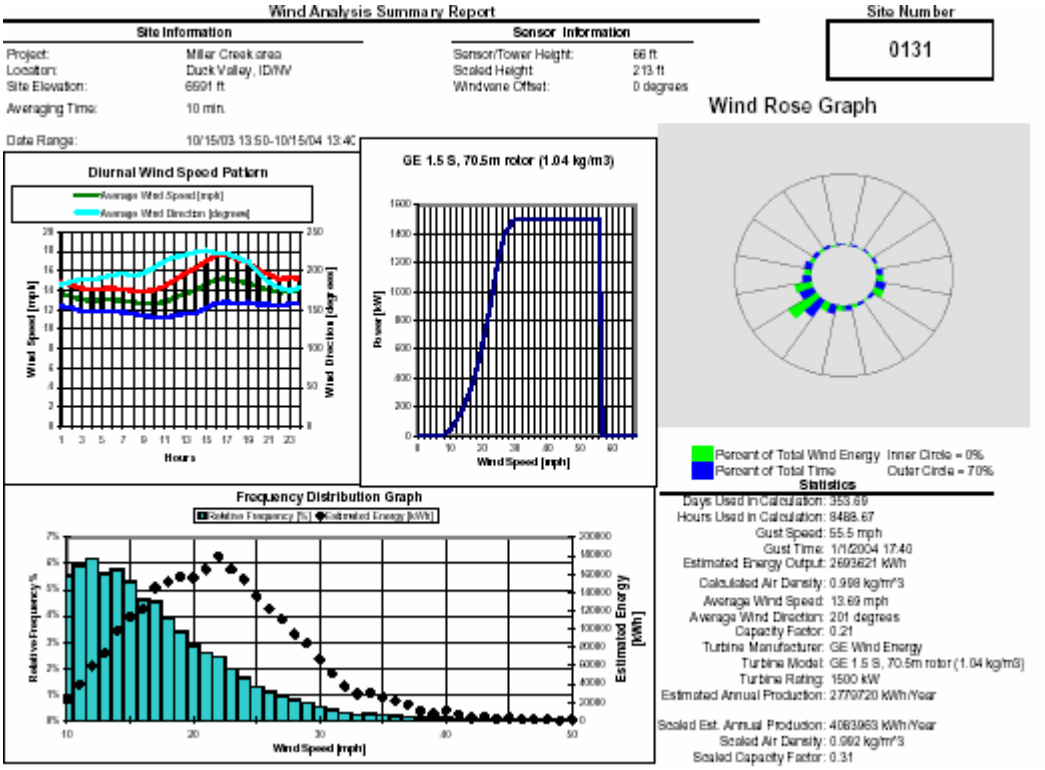
On the following pages:

INEEL Wind Resource Report

Wind Farm Electrical Output and Financial Modeling Results

- 0.14 Shear Scenario
  - Modeling Worksheet
  - Equipment Worksheet
  - Cost Worksheet
  - Financial Worksheet
- 0.20 Shear Scenario
  - Modeling Worksheet
  - Equipment Worksheet
  - Cost Worksheet
  - Financial Worksheet
- 0.26 Shear Scenario
  - Modeling Worksheet
  - Equipment Worksheet
  - Cost Worksheet
  - Financial Worksheet

INEEL Wind Resource Report



RETScreen® Energy Model - Wind Energy Project

Site Conditions		Estimate	Notes/Range
Project name		**0.14 Shear**	
Project location		**Duck Valley**	
Nearest location for weather data		Miller Creek	*See Weather Database*
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	20.0	3.0 to 100.0
Wind shear exponent	-	0.14	0.10 to 0.25
Wind speed at 10 m	m/s	5.6	
Average atmospheric pressure	kPa	91.6	60.0 to 103.0
Annual average temperature	°C	11	-20 to 30

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	1,650	*Complete Equipment Data sheet*
Number of turbines	-	30	
Wind plant capacity	kW	49,500	
Hub height	m	67.0	6.0 to 100.0
Wind speed at hub height	m/s	7.3	3.0 to 15.0
Array losses	%	3%	0% to 20%
Airfoil soiling and/or icing losses	%	2%	1% to 10%
Other downtime losses	%	2%	2% to 7%
Miscellaneous losses	%	3%	2% to 6%

Annual Energy Production		Estimate Per turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	1,650	49,500	
	MW	1.65	49.5	
Unadjusted energy production	MWh	4,165	124,949	
Pressure adjustment coefficient	-	0.90	0.90	0.59 to 1.02
Temperature adjustment coefficient	-	1.01	1.01	0.98 to 1.15
Gross energy production	MWh	3,786	113,579	
Losses coefficient	-	0.90	0.90	0.75 to 1.00
Specific yield	kWh/m²	1,000	1,000	150 to 1,500
Wind plant capacity factor	%	24%	24%	20% to 40%
Renewable energy delivered	MWh	3,421	**102,635**	
	GJ	12316	369484	
				Complete Cost Analysis sheet

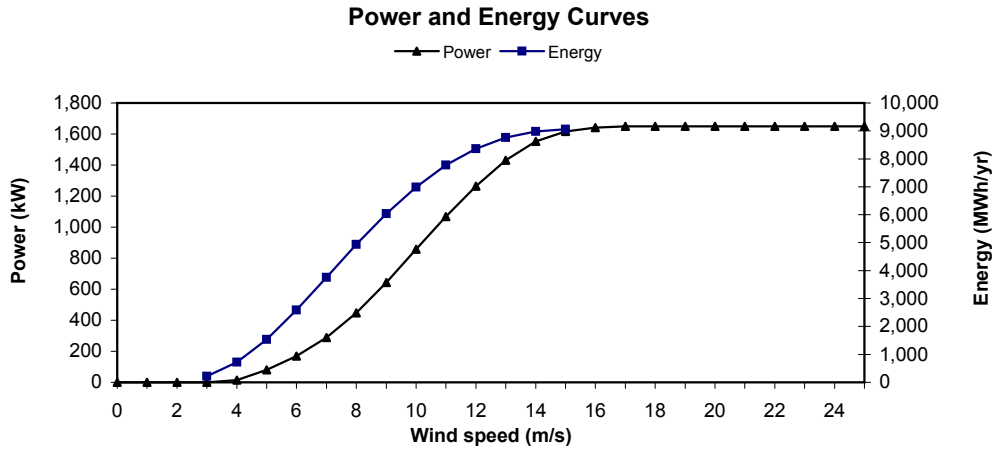
© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	1,650	See Product Database
Hub height	m	67.0	6.0 to 100.0
Rotor diameter	m	66	7 to 72
Swept area	m²	3,421	35 to 4,075
Wind turbine manufacturer		Vestas Wind Systems	
Wind turbine model		VESTAS V66-1.65MW	
Energy curve data source	-	Custom	Weibull wind distribution
Shape factor	-	2.1	1.0 to 3.0

Wind Turbine Production Data

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	0.0	-
1	0.0	-
2	0.0	-
3	0.0	214.7
4	13.5	716.6
5	80.8	1,533.1
6	169.0	2,588.2
7	289.0	3,761.0
8	448.0	4,937.4
9	644.0	6,033.7
10	858.0	6,992.3
11	1,069.0	7,775.8
12	1,263.0	8,366.1
13	1,431.0	8,764.1
14	1,552.0	8,985.6
15	1,617.0	9,055.3
16	1,642.0	-
17	1,649.0	-
18	1,650.0	-
19	1,650.0	-
20	1,650.0	-
21	1,650.0	-
22	1,650.0	-
23	1,650.0	-
24	1,650.0	-
25	1,650.0	-



Return to Energy Model sheet

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Cost Analysis - Wind Energy Project

Type of project: Custom | Currency: $ | Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Site investigation	p-d	6	$ 800	$ 4,800		-	-
Wind resource assessment	met tower	2	$ 40,000	$ 80,000		-	-
Environmental assessment	p-d	24	$ 800	$ 19,200		-	-
Preliminary design	p-d	48	$ 800	$ 38,400		-	-
Detailed cost estimate	p-d	18	$ 800	$ 14,400		-	-
Report preparation	p-d	16	$ 800	$ 12,800		-	-
Project management	p-d	16	$ 800	$ 12,800		-	-
Travel and accommodation	p-trip	8	$ 2,000	$ 16,000		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 198,400**	0.4%		
Development							
PPA negotiation	p-d	20	$ 1,200	$ 24,000		-	-
Permits and approvals	p-d	100	$ 800	$ 80,000		-	-
Land rights	project	0	$ 30,000	$ -		-	-
Land survey	p-d	20	$ 600	$ 12,000		-	-
Project financing	p-d	50	$ 1,500	$ 75,000		-	-
Legal and accounting	p-d	50	$ 1,200	$ 60,000		-	-
Project management	p-yr	1.25	$ 130,000	$ 162,500		-	-
Travel and accommodation	p-trip	18	$ 2,000	$ 36,000		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 449,500**	1.0%		
Engineering							
Wind turbine(s) micro-siting	p-d	100	$ 800	$ 80,000		-	-
Mechanical design	p-d	50	$ 800	$ 40,000		-	-
Electrical design	p-d	100	$ 800	$ 80,000		-	-
Civil design	p-d	90	$ 800	$ 72,000		-	-
Tenders and contracting	p-d	80	$ 800	$ 64,000		-	-
Construction supervision	p-yr	0.85	$ 130,000	$ 110,500		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 446,500**	0.9%		
Renewable Energy (RE) Equipment							
Wind turbine(s)	kW	49,500	$ 600	$ 29,700,000		-	-
Spare parts	%	2.0%	$ 29,700,000	$ 594,000		-	-
Transportation	turbine	30	$ 10,000	$ 300,000		-	-
Other	Cost	49,500	$ 100	$ 4,950,000		-	-
Sub-total:				**$ 35,544,000**	75.1%		
Balance of Plant							
Wind turbine(s) foundation(s)	turbine	30	$ 78,000	$ 2,340,000		-	-
Wind turbine(s) erection	turbine	30	$ 52,000	$ 1,560,000		-	-
Road construction	km	10.00	$ 50,000	$ 500,000		-	-
Transmission line and substation	project	1	$ 1,500,000	$ 1,500,000		-	-
Control and O&M building(s)	building	1	$ 125,000	$ 125,000		-	-
Transportation	project	1	$ 68,000	$ 68,000		-	-
Other	Cost	1	$ 1,000,000	$ 1,000,000		-	-
Sub-total:				**$ 7,093,000**	15.0%		
Miscellaneous							
Training	p-d	40	$ 800	$ 32,000		-	-
Commissioning	p-d	50	$ 800	$ 40,000		-	-
Interest during construction	%	3.0%	$ 43,731,400	$ 1,311,942		-	-
Contingencies	%	5%	$ 43,731,400	$ 2,186,570		-	-
Sub-total:				**$ 3,570,512**	7.5%		
Initial Costs - Total				**$ 47,301,912**	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Land lease	%	2.0%	$ 3,592,209	$ 71,844		-	-
Property taxes	%	0.0%	$ 3,592,209	$ -		-	-
Insurance premium	%	3.0%	$ 3,592,209	$ 107,766		-	-
Transmission line maintenance	%	3.0%	$ 1,500,000	$ 45,000		-	-
Parts and labour	kWh	102,634,537	$ 0.008	$ 821,076		-	-
Community benefits	-	1	$ 15,000	$ 15,000		-	-
Travel and accommodation	p-trip	12	$ 3,000	$ 36,000		-	-
General and administrative	%	6%	$ 1,096,687	$ 65,801		-	-
Other	Cost	0	$ -	$ -		-	-
Contingencies	%	10%	$ 1,096,687	$ 109,669		-	-
Annual Costs - Total				**$ 1,272,157**	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Drive train	Cost	10 yr	$ 1,000,000	**$ 1,000,000**	-	-
Blades	Cost	15 yr	$ 1,000,000	**$ 1,000,000**	-	-
				$ -	-	-
End of project life	Credit	-	$ -	**$ -**		*Go to GHG Analysis sheet*

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Financial Summary - Wind Energy Project

Annual Energy Balance

Project name		0.14 Shear			
Project location		Duck Valley			
Renewable energy delivered	MWh	102,635	GHG analysis sheet used?	yes/no	No
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type		Central-grid			

Financial Parameters

Avoided cost of energy	$/kWh	0.0350	Debt ratio	%	70.0%
RE production credit	$/kWh	0.015	Debt interest rate	%	3.0%
RE production credit duration	yr	10	Debt term	yr	30
RE credit escalation rate	%	2.5%			
			Income tax analysis?	yes/no	No
Energy cost escalation rate	%	3.0%			
Inflation	%	3.5%			
Discount rate	%	12.0%			
Project life	yr	30			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	0.4%	$	198,400	O&M	$	1,272,157
Development	1.0%	$	449,500			
Engineering	0.9%	$	446,500	Debt payments - 30 yrs	$	1,689,316
RE equipment	75.1%	$	35,544,000	**Annual Costs - Total**	**$**	**2,961,473**
Balance of plant	15.0%	$	7,093,000			
Miscellaneous	7.5%	$	3,570,512	**Annual Savings or Income**		
Initial Costs - Total	100.0%	**$**	**47,301,912**	Energy savings/income	$	3,592,209
				Capacity savings/income	$	-
Incentives/Grants		$	-	RE production credit income - 10 yrs	$	1,539,518
				Annual Savings - Total	**$**	**5,131,727**
Periodic Costs (Credits)						
Drive train		$	1,000,000	Schedule yr # 10,20,30		
Blades		$	1,000,000	Schedule yr # 15,30		
		$	-			
End of project life - Credit		$	-			

Financial Feasibility

			Calculate RE production cost?	yes/no	No
Pre-tax IRR and ROI	%	16.6%			
After-tax IRR and ROI	%	16.6%			
Simple Payback	yr	12.3	Project equity	$	14,190,574
Year-to-positive cash flow	yr	5.6	Project debt	$	33,111,338
Net Present Value - NPV	$	4,553,257	Debt payments	$/yr	1,689,316
Annual Life Cycle Savings	$	565,258	Debt service coverage	-	2.34
Profitability Index - PI	-	0.32			

Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(14,190,574)	(14,190,574)	(14,190,574)
1	2,271,983	2,271,983	(11,918,591)
2	2,376,349	2,376,349	(9,542,242)
3	2,483,417	2,483,417	(7,058,825)
4	2,593,258	2,593,258	(4,465,567)
5	2,705,939	2,705,939	(1,759,628)
6	2,821,533	2,821,533	1,061,905
7	2,940,112	2,940,112	4,002,017
8	3,061,753	3,061,753	7,063,770
9	3,186,530	3,186,530	10,250,300
10	1,903,924	1,903,924	12,154,224
11	1,425,831	1,425,831	13,580,055
12	1,509,999	1,509,999	15,090,054
13	1,596,367	1,596,367	16,686,420
14	1,684,989	1,684,989	18,371,410
15	100,573	100,573	18,471,983
16	1,869,223	1,869,223	20,341,206
17	1,964,949	1,964,949	22,306,155
18	2,063,162	2,063,162	24,369,317
19	2,163,921	2,163,921	26,533,238
20	277,501	277,501	26,810,739
21	2,373,331	2,373,331	29,184,070
22	2,482,111	2,482,111	31,666,181
23	2,593,696	2,593,696	34,259,877
24	2,708,153	2,708,153	36,968,030
25	2,825,554	2,825,554	39,793,584
26	2,945,968	2,945,968	42,739,552
27	3,069,468	3,069,468	45,809,020
28	3,196,129	3,196,129	49,005,149
29	3,326,026	3,326,026	52,331,175
30	(2,154,351)	(2,154,351)	50,176,824

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Energy Model - Wind Energy Project

Site Conditions		Estimate	Notes/Range
Project name		**0.2 Shear**	
Project location		**Duck Valley**	
Nearest location for weather data		Miller Creek	*See Weather Database*
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	20.0	3.0 to 100.0
Wind shear exponent	-	0.20	0.10 to 0.25
Wind speed at 10 m	m/s	5.4	
Average atmospheric pressure	kPa	91.6	60.0 to 103.0
Annual average temperature	°C	11	-20 to 30

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	1,650	*Complete Equipment Data sheet*
Number of turbines	-	30	
Wind plant capacity	kW	49,500	
Hub height	m	67.0	6.0 to 100.0
Wind speed at hub height	m/s	7.9	3.0 to 15.0
Array losses	%	3%	0% to 20%
Airfoil soiling and/or icing losses	%	2%	1% to 10%
Other downtime losses	%	2%	2% to 7%
Miscellaneous losses	%	3%	2% to 6%

Annual Energy Production		Estimate Per turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	1,650	49,500	
	MW	1.65	49.5	
Unadjusted energy production	MWh	4,815	144,447	
Pressure adjustment coefficient	-	0.90	0.90	0.59 to 1.02
Temperature adjustment coefficient	-	1.01	1.01	0.98 to 1.15
Gross energy production	MWh	4,377	131,302	
Losses coefficient	-	0.90	0.90	0.75 to 1.00
Specific yield	kWh/m²	1,156	1,156	150 to 1,500
Wind plant capacity factor	%	27%	27%	20% to 40%
Renewable energy delivered	MWh	3,955	**118,650**	
	GJ	14238	427140	
				Complete Cost Analysis sheet

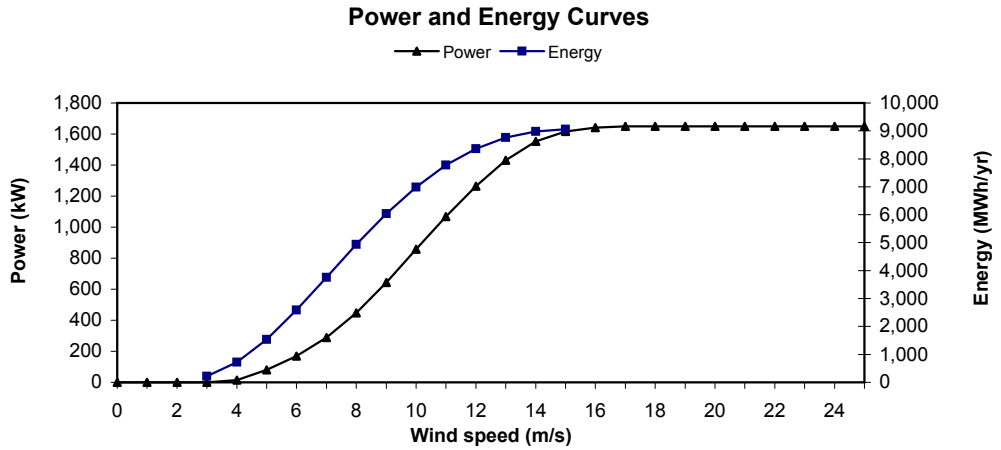
© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	1,650	See Product Database
Hub height	m	67.0	6.0 to 100.0
Rotor diameter	m	66	7 to 72
Swept area	m²	3,421	35 to 4,075
Wind turbine manufacturer		Vestas Wind Systems	
Wind turbine model		VESTAS V66-1.65MW	
Energy curve data source	-	Custom	Weibull wind distribution
Shape factor	-	2.1	1.0 to 3.0

Wind Turbine Production Data

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	0.0	-
1	0.0	-
2	0.0	-
3	0.0	214.7
4	13.5	716.6
5	80.8	1,533.1
6	169.0	2,588.2
7	289.0	3,761.0
8	448.0	4,937.4
9	644.0	6,033.7
10	858.0	6,992.3
11	1,069.0	7,775.8
12	1,263.0	8,366.1
13	1,431.0	8,764.1
14	1,552.0	8,985.6
15	1,617.0	9,055.3
16	1,642.0	-
17	1,649.0	-
18	1,650.0	-
19	1,650.0	-
20	1,650.0	-
21	1,650.0	-
22	1,650.0	-
23	1,650.0	-
24	1,650.0	-
25	1,650.0	-



Return to Energy Model sheet

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Cost Analysis - Wind Energy Project

Type of project: Custom | Currency: $ | Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Site investigation	p-d	6	$ 800	$ 4,800		-	-
Wind resource assessment	met tower	2	$ 40,000	$ 80,000		-	-
Environmental assessment	p-d	24	$ 800	$ 19,200		-	-
Preliminary design	p-d	48	$ 800	$ 38,400		-	-
Detailed cost estimate	p-d	18	$ 800	$ 14,400		-	-
Report preparation	p-d	16	$ 800	$ 12,800		-	-
Project management	p-d	16	$ 800	$ 12,800		-	-
Travel and accommodation	p-trip	8	$ 2,000	$ 16,000		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 198,400**	0.4%		
Development							
PPA negotiation	p-d	20	$ 1,200	$ 24,000		-	-
Permits and approvals	p-d	100	$ 800	$ 80,000		-	-
Land rights	project	0	$ 30,000	$ -		-	-
Land survey	p-d	20	$ 600	$ 12,000		-	-
Project financing	p-d	50	$ 1,500	$ 75,000		-	-
Legal and accounting	p-d	50	$ 1,200	$ 60,000		-	-
Project management	p-yr	1.25	$ 130,000	$ 162,500		-	-
Travel and accommodation	p-trip	18	$ 2,000	$ 36,000		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 449,500**	1.0%		
Engineering							
Wind turbine(s) micro-siting	p-d	100	$ 800	$ 80,000		-	-
Mechanical design	p-d	50	$ 800	$ 40,000		-	-
Electrical design	p-d	100	$ 800	$ 80,000		-	-
Civil design	p-d	90	$ 800	$ 72,000		-	-
Tenders and contracting	p-d	80	$ 800	$ 64,000		-	-
Construction supervision	p-yr	0.85	$ 130,000	$ 110,500		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 446,500**	0.9%		
Renewable Energy (RE) Equipment							
Wind turbine(s)	kW	49,500	$ 600	$ 29,700,000		-	-
Spare parts	%	2.0%	$ 29,700,000	$ 594,000		-	-
Transportation	turbine	30	$ 10,000	$ 300,000		-	-
Other	Cost	49,500	$ 100	$ 4,950,000		-	-
Sub-total:				**$ 35,544,000**	75.1%		
Balance of Plant							
Wind turbine(s) foundation(s)	turbine	30	$ 78,000	$ 2,340,000		-	-
Wind turbine(s) erection	turbine	30	$ 52,000	$ 1,560,000		-	-
Road construction	km	10.00	$ 50,000	$ 500,000		-	-
Transmission line and substation	project	1	$ 1,500,000	$ 1,500,000		-	-
Control and O&M building(s)	building	1	$ 125,000	$ 125,000		-	-
Transportation	project	1	$ 68,000	$ 68,000		-	-
Other	Cost	1	$ 1,000,000	$ 1,000,000		-	-
Sub-total:				**$ 7,093,000**	15.0%		
Miscellaneous							
Training	p-d	40	$ 800	$ 32,000		-	-
Commissioning	p-d	50	$ 800	$ 40,000		-	-
Interest during construction	%	3.0%	$ 43,731,400	$ 1,311,942		-	-
Contingencies	%	5%	$ 43,731,400	$ 2,186,570		-	-
Sub-total:				**$ 3,570,512**	7.5%		
Initial Costs - Total				**$ 47,301,912**	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Land lease	%	2.0%	$ 4,152,750	$ 83,055		-	-
Property taxes	%	0.0%	$ 4,152,750	$ -		-	-
Insurance premium	%	3.0%	$ 4,152,750	$ 124,583		-	-
Transmission line maintenance	%	3.0%	$ 1,500,000	$ 45,000		-	-
Parts and labour	kWh	118,650,011	$ 0.008	$ 949,200		-	-
Community benefits	-	1	$ 15,000	$ 15,000		-	-
Travel and accommodation	p-trip	12	$ 3,000	$ 36,000		-	-
General and administrative	%	6%	$ 1,252,838	$ 75,170		-	-
Other	Cost	0	$ -	$ -		-	-
Contingencies	%	10%	$ 1,252,838	$ 125,284		-	-
Annual Costs - Total				**$ 1,453,292**	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Drive train	Cost	10 yr	$ 1,000,000	**$ 1,000,000**	-	-
Blades	Cost	15 yr	$ 1,000,000	**$ 1,000,000**	-	-
				$ -	-	-
End of project life	Credit	-	$ -	**$ -**		*Go to GHG Analysis sheet*

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Financial Summary - Wind Energy Project

Annual Energy Balance

Project name		0.2 Shear			
Project location		Duck Valley			
Renewable energy delivered	MWh	118,650	GHG analysis sheet used?	yes/no	No
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type		Central-grid			

Financial Parameters

Avoided cost of energy	$/kWh	0.0350	Debt ratio	%	70.0%
RE production credit	$/kWh	0.015	Debt interest rate	%	3.0%
RE production credit duration	yr	10	Debt term	yr	30
RE credit escalation rate	%	2.5%			
			Income tax analysis?	yes/no	No
Energy cost escalation rate	%	3.0%			
Inflation	%	3.5%			
Discount rate	%	12.0%			
Project life	yr	30			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	0.4%	$	198,400	O&M	$	1,453,292
Development	1.0%	$	449,500			
Engineering	0.9%	$	446,500	Debt payments - 30 yrs	$	1,689,316
RE equipment	75.1%	$	35,544,000	**Annual Costs - Total**	**$**	**3,142,608**
Balance of plant	15.0%	$	7,093,000			
Miscellaneous	7.5%	$	3,570,512	**Annual Savings or Income**		
Initial Costs - Total	100.0%	**$**	**47,301,912**	Energy savings/income	$	4,152,750
				Capacity savings/income	$	-
Incentives/Grants		$	-	RE production credit income - 10 yrs	$	1,779,750
				Annual Savings - Total	**$**	**5,932,501**
Periodic Costs (Credits)						
Drive train		$	1,000,000	Schedule yr # 10,20,30		
Blades		$	1,000,000	Schedule yr # 15,30		
		$	-			
End of project life - Credit		$	-			

Financial Feasibility

			Calculate RE production cost?	yes/no	No
Pre-tax IRR and ROI	%	21.7%			
After-tax IRR and ROI	%	21.7%			
Simple Payback	yr	10.6	Project equity	$	14,190,574
Year-to-positive cash flow	yr	4.5	Project debt	$	33,111,338
Net Present Value - NPV	$	9,973,345	Debt payments	$/yr	1,689,316
Annual Life Cycle Savings	$	1,238,128	Debt service coverage	-	2.72
Profitability Index - PI	-	0.70			

Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(14,190,574)	(14,190,574)	(14,190,574)
1	2,908,104	2,908,104	(11,282,470)
2	3,029,385	3,029,385	(8,253,085)
3	3,153,812	3,153,812	(5,099,273)
4	3,281,467	3,281,467	(1,817,806)
5	3,412,429	3,412,429	1,594,624
6	3,546,783	3,546,783	5,141,407
7	3,684,614	3,684,614	8,826,021
8	3,826,009	3,826,009	12,652,030
9	3,971,058	3,971,058	16,623,088
10	2,709,254	2,709,254	19,332,342
11	1,937,300	1,937,300	21,269,642
12	2,035,490	2,035,490	23,305,132
13	2,136,254	2,136,254	25,441,386
14	2,239,656	2,239,656	27,681,042
15	670,415	670,415	28,351,456
16	2,454,642	2,454,642	30,806,098
17	2,566,361	2,566,361	33,372,459
18	2,680,990	2,680,990	36,053,449
19	2,798,602	2,798,602	38,852,051
20	929,481	929,481	39,781,532
21	3,043,069	3,043,069	42,824,601
22	3,170,075	3,170,075	45,994,676
23	3,300,368	3,300,368	49,295,044
24	3,434,028	3,434,028	52,729,073
25	3,571,137	3,571,137	56,300,210
26	3,711,778	3,711,778	60,011,988
27	3,856,038	3,856,038	63,868,025
28	4,004,003	4,004,003	67,872,028
29	4,155,763	4,155,763	72,027,791
30	(1,302,178)	(1,302,178)	70,725,613

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Energy Model - Wind Energy Project

Site Conditions		Estimate	Notes/Range
Project name		**0.26 Shear**	
Project location		**Duck Valley**	
Nearest location for weather data		Miller Creek	*See Weather Database*
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	20.0	3.0 to 100.0
Wind shear exponent	-	0.26	0.10 to 0.25
Wind speed at 10 m	m/s	5.2	
Average atmospheric pressure	kPa	91.6	60.0 to 103.0
Annual average temperature	°C	11	-20 to 30

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	1,650	*Complete Equipment Data sheet*
Number of turbines	-	30	
Wind plant capacity	kW	49,500	
Hub height	m	67.0	6.0 to 100.0
Wind speed at hub height	m/s	8.5	3.0 to 15.0
Array losses	%	3%	0% to 20%
Airfoil soiling and/or icing losses	%	2%	1% to 10%
Other downtime losses	%	2%	2% to 7%
Miscellaneous losses	%	3%	2% to 6%

Annual Energy Production		Estimate Per turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	1,650	49,500	
	MW	1.65	49.5	
Unadjusted energy production	MWh	5,474	164,234	
Pressure adjustment coefficient	-	0.90	0.90	0.59 to 1.02
Temperature adjustment coefficient	-	1.01	1.01	0.98 to 1.15
Gross energy production	MWh	4,976	149,289	
Losses coefficient	-	0.90	0.90	0.75 to 1.00
Specific yield	kWh/m²	1,314	1,314	150 to 1,500
Wind plant capacity factor	%	31%	31%	20% to 40%
Renewable energy delivered	MWh	4,497	**134,903**	
	GJ	16188	485651	
				Complete Cost Analysis sheet

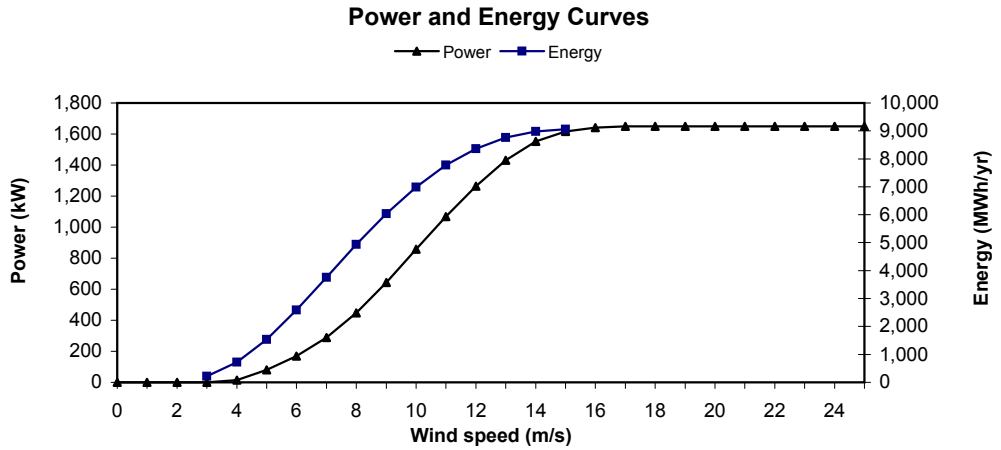
© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	1,650	See Product Database
Hub height	m	67.0	6.0 to 100.0
Rotor diameter	m	66	7 to 72
Swept area	m²	3,421	35 to 4,075
Wind turbine manufacturer		Vestas Wind Systems	
Wind turbine model		VESTAS V66-1.65MW	
Energy curve data source	-	Custom	Weibull wind distribution
Shape factor	-	2.1	1.0 to 3.0

Wind Turbine Production Data

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	0.0	-
1	0.0	-
2	0.0	-
3	0.0	214.7
4	13.5	716.6
5	80.8	1,533.1
6	169.0	2,588.2
7	289.0	3,761.0
8	448.0	4,937.4
9	644.0	6,033.7
10	858.0	6,992.3
11	1,069.0	7,775.8
12	1,263.0	8,366.1
13	1,431.0	8,764.1
14	1,552.0	8,985.6
15	1,617.0	9,055.3
16	1,642.0	-
17	1,649.0	-
18	1,650.0	-
19	1,650.0	-
20	1,650.0	-
21	1,650.0	-
22	1,650.0	-
23	1,650.0	-
24	1,650.0	-
25	1,650.0	-



Return to Energy Model sheet

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Cost Analysis - Wind Energy Project

Type of project: Custom | Currency: $ | Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Site investigation	p-d	6	$ 800	$ 4,800		-	-
Wind resource assessment	met tower	2	$ 40,000	$ 80,000		-	-
Environmental assessment	p-d	24	$ 800	$ 19,200		-	-
Preliminary design	p-d	48	$ 800	$ 38,400		-	-
Detailed cost estimate	p-d	18	$ 800	$ 14,400		-	-
Report preparation	p-d	16	$ 800	$ 12,800		-	-
Project management	p-d	16	$ 800	$ 12,800		-	-
Travel and accommodation	p-trip	8	$ 2,000	$ 16,000		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 198,400**	0.4%		
Development							
PPA negotiation	p-d	20	$ 1,200	$ 24,000		-	-
Permits and approvals	p-d	100	$ 800	$ 80,000		-	-
Land rights	project	0	$ 30,000	$ -		-	-
Land survey	p-d	20	$ 600	$ 12,000		-	-
Project financing	p-d	50	$ 1,500	$ 75,000		-	-
Legal and accounting	p-d	50	$ 1,200	$ 60,000		-	-
Project management	p-yr	1.25	$ 130,000	$ 162,500		-	-
Travel and accommodation	p-trip	18	$ 2,000	$ 36,000		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 449,500**	1.0%		
Engineering							
Wind turbine(s) micro-siting	p-d	100	$ 800	$ 80,000		-	-
Mechanical design	p-d	50	$ 800	$ 40,000		-	-
Electrical design	p-d	100	$ 800	$ 80,000		-	-
Civil design	p-d	90	$ 800	$ 72,000		-	-
Tenders and contracting	p-d	80	$ 800	$ 64,000		-	-
Construction supervision	p-yr	0.85	$ 130,000	$ 110,500		-	-
Other	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 446,500**	0.9%		
Renewable Energy (RE) Equipment							
Wind turbine(s)	kW	49,500	$ 600	$ 29,700,000		-	-
Spare parts	%	2.0%	$ 29,700,000	$ 594,000		-	-
Transportation	turbine	30	$ 10,000	$ 300,000		-	-
Other	Cost	49,500	$ 100	$ 4,950,000		-	-
Sub-total:				**$ 35,544,000**	75.1%		
Balance of Plant							
Wind turbine(s) foundation(s)	turbine	30	$ 78,000	$ 2,340,000		-	-
Wind turbine(s) erection	turbine	30	$ 52,000	$ 1,560,000		-	-
Road construction	km	10.00	$ 50,000	$ 500,000		-	-
Transmission line and substation	project	1	$ 1,500,000	$ 1,500,000		-	-
Control and O&M building(s)	building	1	$ 125,000	$ 125,000		-	-
Transportation	project	1	$ 68,000	$ 68,000		-	-
Other	Cost	1	$ 1,000,000	$ 1,000,000		-	-
Sub-total:				**$ 7,093,000**	15.0%		
Miscellaneous							
Training	p-d	40	$ 800	$ 32,000		-	-
Commissioning	p-d	50	$ 800	$ 40,000		-	-
Interest during construction	%	3.0%	$ 43,731,400	$ 1,311,942		-	-
Contingencies	%	5%	$ 43,731,400	$ 2,186,570		-	-
Sub-total:				**$ 3,570,512**	7.5%		
Initial Costs - Total				**$ 47,301,912**	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Land lease	%	2.0%	$ 4,721,612	$ 94,432		-	-
Property taxes	%	0.0%	$ 4,721,612	$ -		-	-
Insurance premium	%	3.0%	$ 4,721,612	$ 141,648		-	-
Transmission line maintenance	%	3.0%	$ 1,500,000	$ 45,000		-	-
Parts and labour	kWh	134,903,192	$ 0.008	$ 1,079,226		-	-
Community benefits	-	1	$ 15,000	$ 15,000		-	-
Travel and accommodation	p-trip	12	$ 3,000	$ 36,000		-	-
General and administrative	%	6%	$ 1,411,306	$ 84,678		-	-
Other	Cost	0	$ -	$ -		-	-
Contingencies	%	10%	$ 1,411,306	$ 141,131		-	-
Annual Costs - Total				**$ 1,637,115**	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Drive train	Cost	10 yr	$ 1,000,000	**$ 1,000,000**	-	-
Blades	Cost	15 yr	$ 1,000,000	**$ 1,000,000**	-	-
				$ -	-	-
End of project life	Credit	-	$ -	**$ -**		*Go to GHG Analysis sheet*

© Minister of Natural Resources Canada 1997 - 2000.

RETScreen® Financial Summary - Wind Energy Project

Annual Energy Balance

Project name		0.26 Shear			
Project location		Duck Valley			
Renewable energy delivered	MWh	134,903	GHG analysis sheet used?	yes/no	No
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type		Central-grid			

Financial Parameters

Avoided cost of energy	$/kWh	0.0350	Debt ratio	%	70.0%
RE production credit	$/kWh	0.015	Debt interest rate	%	3.0%
RE production credit duration	yr	10	Debt term	yr	30
RE credit escalation rate	%	2.5%			
			Income tax analysis?	yes/no	No
Energy cost escalation rate	%	3.0%			
Inflation	%	3.5%			
Discount rate	%	12.0%			
Project life	yr	30			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	0.4%	$	198,400	O&M	$	1,637,115
Development	1.0%	$	449,500			
Engineering	0.9%	$	446,500	Debt payments - 30 yrs	$	1,689,316
RE equipment	75.1%	$	35,544,000	**Annual Costs - Total**	**$**	**3,326,431**
Balance of plant	15.0%	$	7,093,000			
Miscellaneous	7.5%	$	3,570,512	**Annual Savings or Income**		
Initial Costs - Total	100.0%	**$**	**47,301,912**	Energy savings/income	$	4,721,612
				Capacity savings/income	$	-
Incentives/Grants		$	-	RE production credit income - 10 yrs	$	2,023,548
				Annual Savings - Total	**$**	**6,745,160**
Periodic Costs (Credits)						
Drive train		$	1,000,000	Schedule yr # 10,20,30		
Blades		$	1,000,000	Schedule yr # 15,30		
		$	-			
End of project life - Credit		$	-			

Financial Feasibility

			Calculate RE production cost?	yes/no	No
Pre-tax IRR and ROI	%	26.7%			
After-tax IRR and ROI	%	26.7%			
Simple Payback	yr	9.3	Project equity	$	14,190,574
Year-to-positive cash flow	yr	3.8	Project debt	$	33,111,338
Net Present Value - NPV	$	15,473,880	Debt payments	$/yr	1,689,316
Annual Life Cycle Savings	$	1,920,984	Debt service coverage	-	3.10
Profitability Index - PI	-	1.09			

Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(14,190,574)	(14,190,574)	(14,190,574)
1	3,553,667	3,553,667	(10,636,907)
2	3,692,113	3,692,113	(6,944,794)
3	3,834,158	3,834,158	(3,110,636)
4	3,979,891	3,979,891	869,255
5	4,129,406	4,129,406	4,998,660
6	4,282,798	4,282,798	9,281,458
7	4,440,166	4,440,166	13,721,624
8	4,601,609	4,601,609	18,323,233
9	4,767,231	4,767,231	23,090,464
10	3,526,536	3,526,536	26,617,000
11	2,456,360	2,456,360	29,073,361
12	2,568,780	2,568,780	31,642,141
13	2,684,154	2,684,154	34,326,295
14	2,802,556	2,802,556	37,128,851
15	1,248,714	1,248,714	38,377,564
16	3,048,750	3,048,750	41,426,315
17	3,176,698	3,176,698	44,603,013
18	3,307,988	3,307,988	47,911,001
19	3,442,703	3,442,703	51,353,704
20	1,591,138	1,591,138	52,944,842
21	3,722,746	3,722,746	56,667,588
22	3,868,251	3,868,251	60,535,839
23	4,017,530	4,017,530	64,553,369
24	4,170,677	4,170,677	68,724,046
25	4,327,786	4,327,786	73,051,832
26	4,488,955	4,488,955	77,540,787
27	4,654,282	4,654,282	82,195,069
28	4,823,867	4,823,867	87,018,936
29	4,997,815	4,997,815	92,016,751
30	(437,357)	(437,357)	91,579,394

© Minister of Natural Resources Canada 1997 - 2000.