Lutselk'e Wind Energy Pre-Feasibility Analysis

Prepared for

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Executive Summary

This study provides a pre-feasibility assessment of the wind energy potential in the Lutselk'e area.

Lutselk'e is a community of over 320 people located on a peninsula on the south shore of the east arm of Great Slave Lake (Christie Bay). The average power use in the community is 190 kilowatts (kW) and the projected energy requirement is 1,700 megawatt-hours (MWh) for the year 2011.

A potential wind development project site has been identified close to the community on a ridge located south of the airport. The ten-year average wind speed at the airport was measured to be 3.21 m/s at a height of 10 m above the surface. Using a computer wind flow model the wind speed was estimated to be 6.2 m/s at 30 m above surface at the proposed project site.

Given the community power load (190 kW), four wind turbine options were selected for this study: a 100 kW NorthWind 100 Arctic version, two 50 kW AOC 15/50s, two 55 kW Endurance E-3120s, and three 35 kW Wenvor 30s. These different wind energy projects ranged from $2.4 to $2.6 million to build. The cost per installed kilowatt ranges from $20,400 to $25,500. A large portion of the wind project cost lies in the construction of a 5.5 km power line required for the project, which is estimated at $1 million. Excluding the power line brings the installed cost of these projects to a range of $11,000 to $14,500 per kW.

The levelized cost of energy produced from an unsubsidized wind project with a 20 year life was estimated to cost from $0.998 to $1.599 per kWh. The 20 year levelized cost of diesel generation is $0.371 per kWh for fuel costing $1.00 per litre and $0.455 per kWh for fuel costing $1.25 per litre. The wind project will be competitive when diesel cost reaches $2.90 per litre.

In the North, the impact of capital costs on the price of wind energy is very significant. The authors have provided capital and operating cost estimates on the basis that experienced developers and operators will be completing and operating the projects. Cost estimates do not make allowances for this project being a first in the territory and thus incurring extra costs. However, the authors also believe that with experience there is still room to lower the capital costs for wind projects in Northwest Territories.

Getting the federal government to adopt Canadian Wind Energy Association's (CanWEA) proposed Northern and Remote Wind Incentive Program is very high on CanWEA's list of priorities. Other factors such as reduced capital cost, reduced operating cost, or increased diesel fuel cost (or revenue from carbon credits or green attribute sales) would serve to further increase the competitiveness of a wind project.

A 100-120 kW wind project in Lutselk'e could reduce annual diesel fuel consumption by 42,000 to 73,000 litres, reducing greenhouse gas emissions by 127 to 220 tonnes per year.

Considering that a wind project would cost roughly three times the cost of diesel generation, other renewable sources of energy such as hydro or solar should be considered. Should wind energy development be considered seriously for Lutselk'e, then a wind monitoring station should be installed at the identified site to verify the projected wind speeds used in this analysis.

Background

JP Pinard, P.Eng., Ph.D. and John Maissan, P.Eng. of Leading Edge Projects Inc. (the authors) have been retained by the Aurora Research Institute (ARI) to conduct a pre-feasibility study for wind energy generation in Lutselk'e. This study examines wind data from the airport station, maps, and satellite images and makes use of a computer modelling tools to identify potential wind monitoring sites around the community. In addition, the project group has obtained information about the current and future power systems in Lutselk'e from Northwest Territories Power Corporation's (NTPC) web site and their 2006/2007 – 2007/2008 General Rate Application (GRA) to the Northwest Territories Public Utilities Board (NWT PUB, see NTPC 2008b). This study provides the information listed below.

1) An analysis of local wind measurements to estimate long-term mean wind speed and direction.
2) Estimates of the wind speeds around the hamlet generated with computer models.
3) A list of potential locations for wind monitoring equipment.
4) A description of the power system in the hamlet which includes the size, capacity and condition of present system.
5) An analysis of the potential wind energy production from different wind turbine models.
6) Preliminary estimates of the cost of wind generation for the hamlet.
7) Estimates of power production and fuel displacement through integration of wind power.
8) An outline of next steps needed to pursue the integration of wind power in the hamlet.

Introduction

Lutselk'e is a community of over 320 people located on a peninsula on the south shore of the east arm of Great Slave Lake (Christie Bay). It was formerly known as Snowdrift. Lutselk'e is 190 km east of Yellowknife and is at an altitude of 168 m above sea level (ASL). The community is not accessible by road but there is a small airport with scheduled services from Yellowknife. In the summer a sealift (barge) is operated by Northern Transportation Company Limited from Hay River.

The main source of electricity for the community is through the diesel plant that is operated by NTPC. The diesel plant has a total capacity of 820 kW consisting of three diesel generators rated at 180, 320 and 320 kW. Fuel is barged in from Hay River on an annual basis, usually in late June or early July, and occasionally once more late in the season.

No previous wind resource assessment work has been carried out in Lutselk'e. The Northwest Territories Power Corporation (NTPC) however, has been conducting a feasibility study on a mini-hydro project on the Snowdrift River (NTPC, 2008a). The project proposal is to build a 500 to 1000 kW mini-hydro plant to serve the electricity and heating requirements for the community. If the project goes ahead it will reduce the community's annual diesel fuel consumption by about 800,000 litres, approximately 400,000 litres of which is currently used to generate electricity (the rest is likely used for space heating).

The purpose of this report is to examine the potential for wind power generation by identifying potential sites and estimating the mean annual wind speed for those sites. The economic analysis looks at the cost of building a wind project near the hamlet using a selection of different wind turbine options.

The analysis also includes estimates of the levelized cost per kWh of production over 20 years, subsidy requirements, and greenhouse gas savings.

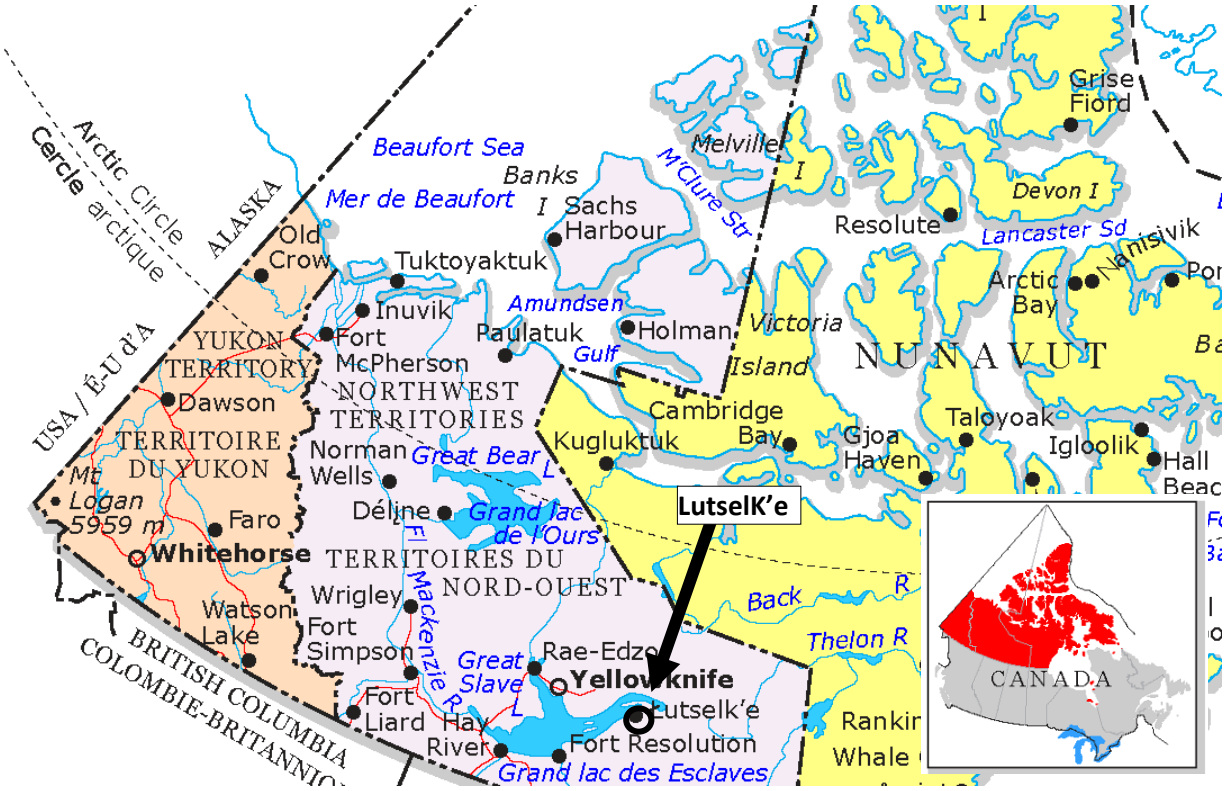

Figure 1: Lutselk'e is on the south shore of Great Slave Lake approximately 190 km east of Yellowknife.

Suitable Site for Wind Energy Development

When investigating suitable sites for potential wind projects, there are several criteria that are strongly desired in order to keep costs low and the project possible. The wind project should be as close to the community and its electrical load as possible, typically within a few hundred metres. Ideally the wind project should be outside the limitation of the airspace around the local airport (at least 4km away), as this avoids height restrictions by airport regulations. And the wind project location must be accessible by road, be acceptable to the community, and not infringe on other land uses. The project location also requires exposure to sufficient wind resources. Typically we find that the best winds are located on hilltops near open water because wind speeds increase with altitude and over smoother surfaces.

The Hamlet of Lutselk'e is located at a height of 168 m ASL on a small peninsula that juts out into Christie Bay, on the south shore of the east arm of the Great Slave Lake. The airport is located about 3 km east of the village. The power line to the airport appears to be a single phase line. There are two prominent ridges near the community. One ridge is located right next to the community at a height of about 245 m above sea level (ASL); however is it aligned with the local airport and a wind project there will be in direct conflict with the flight path. The other ridge is about 3.2 km southeast of the community and peaks at 335 m ASL, and is about 170 meters higher than the community and the airport. This ridge starts just south of the airport and tends south, parallel to the eastern shore of the peninsula. It has

good exposure to winds from the lake in all but the southerly direction. This ridge is approximately 2 km long and has several possible sites for a potential wind project. The high point on the ridge is very close to an existing road which heads south of the community for a relatively short distance. The ridge is, however, within a 4 km radius of the airport and may interfere with airport regulation on airspace obstruction. As well, a wind project on this site would require about 5.5 km of three-phase power line to be built – a very expensive proposition for a small project.

There are no other potential wind development sites closer to the community that would have the similar altitudes.

Figure 2: Map of area around Lutselk'e. Contour interval is 10 m starting with lowest contour at 165 m ASL.

Estimating the Wind Climate in the Lutselk'e Area

To estimate the wind energy potential in Lutselk'e, wind speed measurements are required. The wind data used for the wind analysis was extracted from Environment Canada's (EC) climate data, which is available online at their website (www.climate.weatheroffice.ec.gc.ca). According to EC there is a climate (weather) station at the airport (see Figure 2). The data from this station contain hourly measurements of wind speed and direction, temperature, pressure, humidity, and other parameters. The wind measurements at this station appear to be made at 10 m above ground level (AGL).

Wind data was collected from the website for the 10-year period 2001 to 2010. The 10-year mean wind speed from this set is 3.21 m/s from a height of 10 m AGL at a surface elevation of 179 m ASL (although as seen in Figure 2 above the station appears to be at 175 m ASL based on the contour lines). Figure 3 shows a time series of monthly mean wind speeds at the airport. An analysis of the time series shows no significant trend in the average annual wind speed over the ten-year period. Note that on average the monthly wind speed reaches a minimum in January and a maximum in May.

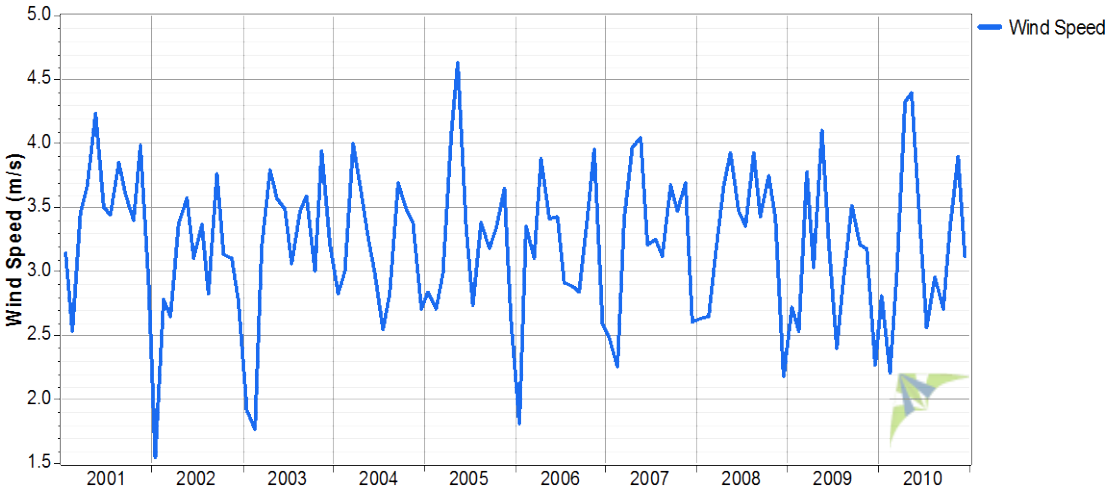

Figure 3: A time series graph of monthly mean wind speed at the Environment Canada climate station by the Lutselk'e Airport.

Wind direction must also be taken into account when considering a wind energy project. A wind rose provides an indication of the dominant wind direction of the area and is very useful for planning the location of a wind project to ensure its maximum capture of wind energy. In Figure 4, the wind rose for Lutselk'e has a solid shaded area that represents the relative wind energy by direction. The wind energy by direction is calculated as the frequency of occurrence of the wind in a given direction sector multiplied by the cube of the mean wind speed in the same direction. The given wind energy in each direction is a fraction of the total energy for all directions. According to the wind rose, the wind energy at Lutselk'e comes from one dominant direction: the east-northeast. Therefore, a wind energy project established in the region should have good exposure to the east-northeast. In the next stage of analysis, the information from the wind rose and the EC wind speed data are used to run a wind flow model that calculates and visualizes where the best wind sites might be for the Lutselk'e area.

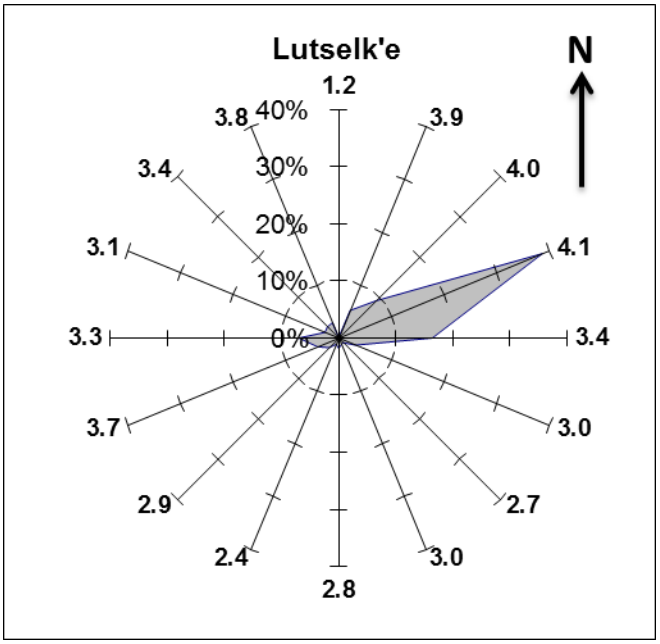

Figure 4: Wind rose showing the wind energy by direction for Lutselk'e. The numbers at the end of each axis indicate the average wind speed for that direction. This rose shows that the dominant wind direction is from the east-northeast.

Fine-Scale Wind Modelling of the Lutselk'e Area

The wind model used to create the wind map for the area is OpenWind by AWS Truewind (www.awstruewind.com). OpenWind uses a mass-consistent wind flow model to project winds from one location to another. As input, the model uses surface elevation data, surface roughness information, and a table of wind speed distribution by direction. The elevation data is obtained from the Geobase website (http://www.geobase.ca). The average surface roughness is assumed to be z_o = 0.2 m, which is representative of the area's forest type and density. The table of wind speed distribution is derived from the ten years of wind speed data (2001-2010) obtained from the Environment Canada website for the Lutselk'e weather station.

The wind flow modeling portion of OpenWind creates a wind map for each wind flow direction. The wind speeds in the wind maps are directly associated to the table of wind speed distributions. All of the wind maps are then amalgamated to produce one summary map. The OpenWind wind speed map in Figure 5 shows the summarized wind speed contours over a satellite image of Lutselk'e. On a ridge south of Lutselk'e, the long term average annual wind speed is estimated from the wind flow model to be approximately 6.5 m/s at 30 m AGL, making it a good location for placing wind turbines. The authors have downgraded this wind speed to 6.2 m/s as a more conservative estimate to be used for the economic analysis. The wind speed identified at this location is used as the basis for energy modelling using select wind turbines in an energy model called HOMER that will be described later.

Figure 5: A satellite image of the Lutselk'e area superimposed by a contour line of modelled wind speeds at 30 m AGL. The wind speed contour interval is 0.5 m/s. All wind speed contours below 4.5 m/s are not shown. The highest wind speed contour is 6.5 m/s and it appears where the proposed wind project site is indicated.

Power Requirements and Costs

The community of Lutselk'e has its electricity requirements supplied by an NTPC diesel power plant consisting of three generators (one 180 kW and two 320 kW generators, for a total capacity of 820 kW). The most recent NTPC GRA (general rate application, see NTPC 2008b) indicates that the fuel efficiency of the diesel plant is 3.778 kWh per litre.

The 2007/8 actual power requirement in the community was 1,647 MWh and the authors projected that with the load growth trend illustrated in the GRA, this would have grown to about 1,700 MWh in 2011. This represents an average diesel plant load of about 194 kW and a peak load of about 375 kW (based on the GRA 2007/2008 forecasted load factor of 51.7%). The authors estimated that the minimum plant

load would be in the order of 100 kW. Relevant excerpts of the GRA and other NTPC documents are attached as Appendix 1.

For this prefeasibility study, a wind project size of about 100 kW was selected. This represents a low to medium penetration level project, but is probably as small as is practical. A single smaller turbine project could have been considered but such a small project would lack all economies of scale and displace less diesel generation. This study did not examine a high penetration project as the authors feel that more experience with simpler wind-diesel projects in NWT is required before more technically complicated high penetration systems are taken on.

For the purposes of this study it has also been assumed that the NTPC diesel power plant would generate 3.8 kWh per litre of diesel fuel. This diesel plant would produce variable (or incremental) electrical energy at a levelized cost of $0.371 per kWh over 20 years with diesel fuel starting at $1.00 per litre ($0.455 per kWh with diesel fuel starting at $1.25 per litre). These costs include only fuel and variable operation and maintenance (O&M) costs. Other relevant assumptions are: variable diesel O&M expense is $0.03 per kWh (the Yukon Utilities Board accepted average variable diesel O&M cost in Yukon for Yukon Energy and The Yukon Electrical Company Limited) and diesel fuel is assumed to inflate at 3% per year with general inflation running at 2% per year.

Wind Power Project Costs

Developer – Operator

For the purpose of this report it was assumed that a wind project would be a medium penetration project: it would be large enough so as to displace a reasonable amount of diesel consumption without compromising the quality of the electric grid. A larger wind project would require a more complex power and energy control system to divert the excess wind energy. This would create an opportunity to utilise the excess wind energy for space heating (and eventually, local transportation) which would add greater benefits to the community at large. This level of high contribution (high penetration) has however, not been implemented to any great extent in Canada. High penetration systems are being used in Alaska and Australia and should be considered as a future phase for a project in this community.

For this report it is also assumed that if a wind project were to be developed in Lutselk'e it would be done by a developer with some amount of wind project experience in the NWT. There is no allowance in the project cost estimates for overcoming a learning curve for inexperienced developers/operators. If a project were to be developed by an inexperienced firm the capital costs would likely be higher. In the opinion of the authors, the ideal project developer/operator would be NTPC as they already own the diesel power plant, have significant technical resources, and have experience in construction in the remote communities. As well, the integration of the wind and diesel plants (including power purchase agreement issues) would be relatively seamless.

Wind Turbines

Based in part on other recent work by the authors four wind turbine models were selected for consideration at Lutselk'e. These include Northern Power Systems' NorthWind 100 (100 kW capacity with a 21 m rotor diameter), the AOC 15/50 (60kW with a 15 m rotor) now supplied and supported by Seaforth Engineering (Seaforth purchased Entegrity Wind Systems' assets and Intellectual Property), the Endurance E-3120 (55kW with a 19.2 m rotor), and the Wenvor 30 (35kW with a 10 m rotor). Since there may well be cost and other practical advantages in using smaller tilt-up wind generators in remote communities the Wenvor 30 was included in the report. For convenience the NorthWind 100 is referred to as the NW100. Both of the NW100 and the AOC 15/50 turbines have available options for operation down to -40°C (included in the authors' pricing) and estimated costs for low temperature operations were included in the E-3120 and Wenvor 30 pricing.

Energy Production

The annual energy production from each of the selected wind turbines is calculated using the HOMER model. HOMER was developed by the National Renewable Energy Laboratory of the US Government and is now distributed and supported by HOMER Energy (www.homerenergy.com). HOMER is a power system analysis and optimization model. The energy model uses published wind turbine power curves, diesel plant production specifications, and one-year hourly time series measurements of both wind speed and community power load to model the energy output of various power generators.

The inputs for the HOMER model consist of the three diesel generators described earlier, the wind system and the community load data. The wind resource data used as input for the HOMER is a one-year data set synthesized from the ten-year data set from the climate station measurements at the Lutselk'e airport. This wind data when modeled in the OpenWind wind flow model resulted in a prediction of an average annual wind speed of 6.2 m/s.

The energy produced by each of the selected turbine configurations are based on the published power curves, less 5% to adjust for a turbine availability of 95%. An additional 10% of the production is then subtracted to account for losses (turbulence losses, array losses, mechanical losses, cold and icing performance losses, transformer losses, and transmission line losses) to arrive at the net energy production available to displace diesel energy. Appendix 2 presents a table of energy production from the four different wind turbine models described. Often there is an adjustment for increased production at higher air densities due to cold temperatures which, in this case, would likely be 5% or a bit higher. However, to be conservative no air density adjustments were made in this study.

The calculations indicate that the net energy production at the annual average wind speed at the turbine hub height represents a capacity factor of about 24% for the NW100, 22% for the two AOC 15/50s, 30% for the two E-3120s, and 18% for the three Wenvor 30 turbines. The Endurance E-3120 turbines have a higher capacity factor largely because of their larger rotor diameter designed for low to moderate wind climates. Net generation is the HOMER calculated ideal generation less availability and other losses (total 15% of ideal generation).

Capital Costs

The estimated capital costs for the projects of approximately 100 kW are presented in Appendix 3 and are summarized below:

1. A 100 kW project based on one NW100 turbine was estimated to cost about $2.555 million or $25,547 per kW;
2. A 120 kW project based on two AOC 15/50 turbines was estimated to cost about $2.443 million or $20,363 per kW;
3. A 110 kW project based on two E-3120 turbines was estimated to cost about $2.592 million or $23,564 per kW; and
4. A 105 kW project based on three Wenvor 30 turbines was estimated to cost about $2.391 million or $22,773 per kW.

The most significant fixed cost item is the 5.5 km power line required to connect wind turbines on the ridge to the community's power system. This line is estimated to cost $1 million and is not a function of project size. Other major cost items include the foundation design and the associated geotechnical work at about $110,000 to $130,000, and the integration with the diesel plant/power system estimated at about $100,000. The mobilization and demobilization of a crane at about $100,000 for the NW100 turbine could be higher if good coordination is lacking with the barge service and turbine installation.

To examine the potential benefit of capital cost reductions the authors analyzed the four cases with the $1 million power line eliminated (see Appendix 4). This reduced the capital costs and the ultimate cost of energy for each of the four project configurations. The reduced capital cost project options can be summarized as follows:

1. A 100 kW project based on one NW100 turbine was estimated to cost about $1.455 million or $14,547 per kW;
2. A 120 kW project based on two AOC 15/50 turbines was estimated to cost about $1.344 million or $11,196 per kW;
3. A 110 kW project based on two E-3120 turbines was estimated to cost about $1.492 million or $13,564 per kW; and
4. A 105 kW project based on three Wenvor 30 turbines was $1.291 million or $12,297 per kW.

The capital costs of a wind project are a major energy cost driver, so it is critical for any developer to pay considerable attention to all capital cost components. Larger projects provide economies of scale that reduce costs per unit of installed capacity and for this reason the authors chose projects of about 100 kW for this study.

Operating and Maintenance Costs

The annual operating and maintenance cost for a project of about 100kW in size was estimated to be about $25,000 based on other recent work by the authors. This cost is based on the simple

requirements to keep a project running and does not include costs that may be associated with establishing and running a corporation for the wind project only. The effective assumption is that the wind project is owned and operated by an appropriate existing organization.

The operating and maintenance cost is intended to include all overhead, insurance, lease, and tax costs as well as the actual maintenance costs. This is equivalent to $0.09 to $0.15 per kWh, depending on the turbine, for the estimated production in an annual average wind speed of 6.2 m/s.

For the economic analysis (presented in the following subsection) the cost of capital was assumed to be 7.5%, which represents a regulated utility. Incorporated in the cost of capital is a return on equity which would be earned by the project owners and is separate and distinct from the annual operating and maintenance costs. The authors believe that funding assistance would likely be necessary to interest a wind project developer and this would increase the effective return on equity or reduce the cost of debt. A project developer would need to calculate the economics of a project based on their own circumstances.

Cost of Wind Energy and Economic Analyses

The levelized cost of wind energy over a 20 year project life was calculated to compare the cost of wind generated electricity to the cost of diesel generation. Appendix 5 presents the economic model outputs of the levelized cost of wind energy for the four project variations both with and without the 5.5 kilometer power line and Appendix 6 presents the economic model outputs for continued diesel generation. The variables and assumptions used in the economic model include the project capital cost, its capacity in kW, its annual diesel displacing energy production, the useful life of a wind project (20 years), the cost of capital (7.5%), the general inflation rate (2%), and the annual operating costs. The model calculates the levelized cost of energy over the life of the projects.

For continued diesel generation, the assumptions include a variable operating and maintenance cost of $0.03 per kWh, a plant efficiency of 3.8 kWh per litre, and diesel fuel is assumed to inflate at 3% per year while general inflation is 2% per year. As the authors were unable to obtain present diesel fuel pricing from NTPC, present fuel prices of $1.00 per litre and $1.25 per litre were considered. Table 1 below summarizes the results of the economic modelling.

The economic analyses summarized in Table 1 below indicate that although there is fairly significant variation in the levelized cost of energy for different wind turbine options, which is largely a function of the energy capture due to variations in swept area per unit capacity, wind energy is a long way from being cost competitive with continued diesel generation. Even when the high capital cost power line was removed from the wind projects all wind project configurations were still more costly than diesel generation. Very high levels of subsidy would be required to make a wind project cost competitive with diesel generation. The Canadian Wind Energy Association's proposed Northern and Remote Wind Incentive Program subsidies providing up to $4,000 per kW of installed capacity would not be adequate to make a wind project economic unless the power line was also provided at no cost.

Table 1: 20-year levelized cost of energy for wind projects and continued diesel generation.

Project Configuration	20 year Levelized Cost of Energy ($ per kWh)	
	With Power Line	Without Power Line
Three Wenvor turbines	$1.599	$0.947
Two Endurance E-3120 turbines	$0.998	$0.619
Two Seaforth AOC 15/50 turbines	$1.173	$0.703
One Northwind 100 turbine	$1.286	$0.781
Diesel generation, $1.00 per litre	$0.371	
Diesel generation, $1.25 per litre	$0.455	

The Endurance E-3120 with its large rotor would generate the most energy and thus the lowest cost electrical energy. The Wenvor with its relatively smaller rotor would generate the least electrical energy and thus the highest cost energy. The AOC and Northwind turbines fall in between the Endurance and Wenvor machines with respect to energy production and levelized energy cost.

In the authors' view it is the small scale of the wind project options and the very high cost of project construction in remote communities that drives the wind energy cost out of reach. It is likely that the levelized cost of energy from wind projects is as high, or higher, than it would be from roof-top solar PV located right in the community. Recent work by the authors indicates that the levelized cost for solar PV energy could be in the range of $0.70 to $1.00 per kWh in Yukon.

It is possible that with an experienced wind project development industry based on other projects in the Northwest Territories a more cost effective project could be installed in Lutselk'e but this is likely some time off in the future. Until then other renewable energy options for Lutselk'e should be considered.

Greenhouse Gas Reductions

Table 2 outlines the diesel fuel and greenhouse gas (GHG) reductions that would be achieved by wind projects of about 100 kW at an annual average wind speed of 6.2m/s. The calculations are based on a diesel plant efficiency of 3.8 kWh per litre, and GHG emissions of 3.0 kg carbon dioxide (CO_2) equivalent per litre of diesel fuel consumed.

Table 2: Annual GHG reductions from a 100 kW wind project in Lutselk'e.

Project Configuration	Diesel Electricity Displaced (kWh)	Diesel Fuel Saved (litres)	GHG Reductions (kg CO_2 equivalent)
Three Wenvor 30s	161,674	42,546	127,637
Two E-3120s	278,218	73,215	219,646
Two AOC 15/50s	224,691	59,129	177,388
One NW 100	208,562	54,885	164,654

Conclusions

1. The ridge south of Lutselk'e is the only potential wind development site in the area. It is about 5.5 km from the community and has road access.
2. Based on local airport weather data and computer modelling, the wind speed at 30 m AGL on the ridge is projected to be 6.2 m/s.
3. Capital costs for a wind project of about 100 kW would range from $2.4 to $2.6 million, depending on the turbine model selected.
4. Capital costs for a project of about 100 kW but without the $1 million power line would range from $1.3 to $1.5 million, depending on the turbine model selected.
5. In a forecasted wind resource of 6.2 m/s, a wind project with a power line would produce power at a levelized cost of $0.998 to $1.599 per kWh depending on the turbine selected, and without the power line the levelized cost for energy would range from $0.619 to $0.947 per kWh.
6. The Endurance E-3120 with its large swept area per kW of capacity would produce the lowest cost energy and the Wenvor with its relatively small swept area per kW of capacity would produce the highest cost energy.
7. At a wind speed of 6.2 m/s a 100 kW project would displace 42,546 to 73,215 litres of diesel fuel per year and reduce GHG emissions by 127,637 to 219,646 kg of CO_2 equivalent per year.

Next Steps

1. Renewable energy sources other than wind should be examined if the aim is to reduce diesel generation.
2. Should wind energy development be considered seriously for Lutselk'e, a wind monitoring mast should be installed at the identified project site.
3. Following confirmation of the wind resource, a detailed feasibility study could be carried out. Particular attention is required to minimize capital costs and identify any available support programs.
4. Should Lutselk'e wish to pursue a wind energy development, a significant level of subsidies would be required to make the project cost-effective.

Reference

NTPC, 2008a. Northwest Territories Power Corporation 2008/09 Greenhouse Gas Report. By NTPC (Northwest Territories Power Corporation). www.ntpc.com.

NTPC, 2008b. NTPC 2006/07 & 2007/08 Phase II GRA and Rate Finalization Application. www.ntpc.com

Appendix 1

Schedule A.6

Northwest Territories Power Corporation
2006/07 - 2007/08 General Rate Application
Summary of Generation, Sales, and Revenue
110 Lutselk'e

Line no.	Description	2002/03 Negotiated Settlement	2004/05 Actual	2005/06 Actual	2006/07 Forecast @ Existing Rates	2007/08 Forecast @ Existing Rates
	SALES AND REVENUE					
	Residential					
1	Sales (MWh)	710	739	689	705	723
2	Customers	122	118	122	120	122
3	Av. MWh Sales/Cust.	5.82	6.26	5.65	5.88	5.91
4	Revenue (000s)	467	484	454	463	475
5	Cents /kWh	65.77	65.47	65.89	65.73	65.72
	General Service					
6	Sales (MWh)	583	661	677	686	697
7	Customers	33	36	36	38	40
8	Av. MWh Sales/Cust.	17.91	18.36	18.80	17.97	17.56
9	Revenue (000s)	355	398	408	414	421
10	Cents /kWh	60.92	60.21	60.24	60.34	60.49
	Wholesale					
11	Sales (MWh)					
12	Customers					
13	Revenue (000s)					
14	Cents /kWh					
	Industrial					
15	Sales (MWh)					
16	Customers					
17	Av. MWh Sales/Cust.					
18	Revenue (000s)					
19	Cents /kWh					
	Streetlights					
20	Sales (MWh)	29	29	29	29	30
21	Revenue (000s)	22	31	31	32	32
22	Cents /kWh	76.60	107.57	107.31	109.50	107.39
	Total Community					
23	**Sales (MWh)**	**1,322**	**1,429**	**1,395**	**1,420**	**1,450**
24	Customers	154	**154**	**158**	**158**	**162**
25	Revenue (000s)	844	**913**	**893**	**909**	**929**
26	Cents /kWh	63.87	63.89	64.02	64.02	64.06
	GENERATION (MWh)					
27	**Total Station Service**	103	87	96	96	96
28	**Total Losses**	94	80	79	90	92
29	***Losses - % of Gen.***	*6.2%*	*5.0%*	*5.0%*	*5.6%*	*5.6%*
30	**Total Generation**	**1,519**	**1,595**	**1,570**	**1,607**	**1,638**
	Source (MWh)					
31	Hydro Generation					
32	Gas Generation					
33	Gas Efficiency					
34	*Cubic Meters (000s)*					
35	Diesel Generation	1,519	1,595	1,570	1,607	1,638
36	Diesel Efficiency	3.793	3.792	3.772	3.778	3.778
37	*Liters (000s)*	*400*	*421*	*416*	*425*	*433*
38	Purchased Power					
39	Total Generation	1,519	1,595	1,570	1,607	1,638
	% of Total Generation					
40	Hydro					
41	Gas					
42	Diesel	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*
43	Purchased					
	Peak (kW)					
44	Total Peak	356	360	340	355	361
45	Load Factor	48.8%	50.6%	52.7%	51.7%	51.7%

NORTHWEST TERRITORIES POWER CORPORATION **Schedule 3.3.2**

2007/08 FORECAST PRODUCTION FUEL COST

Line No.	Plant No.		Generation (kWh)	Plant Efficiency (kWh/L)	Fuel Required (Litres)	Fuel Price ($/L)	Fuel Cost ($000's)
1	101	Yellowknife	1,379,000	3.500	394,000	0.755	297
2	104	Wha Ti	1,730,422	3.711	466,256	0.897	418
3	105	Gameti	975,320	3.398	287,008	0.927	266
4	108	Behchoko	21,125	3.250	6,500	0.778	5
5	110	Lutsel K'e	1,637,723	3.778	433,468	0.896	388
6	201	Fort Smith	465,700	3.277	142,102	0.793	113
7	203	Fort Resolution	60,000	3.459	17,345	0.860	15
8	205	Fort Simpson	8,238,565	3.755	2,193,767	0.862	1,890
9	206	Fort Liard	2,719,334	3.725	730,105	0.877	641
10	207	Wrigley	667,892	3.525	189,491	0.885	168
11	208	Nahanni Butte	372,594	2.511	148,360	0.877	130
12	209	Jean Marie River	339,598	2.749	123,547	0.858	106
13	301	Inuvik Power - D	1,675,500	3.635	460,935	0.797	367
14	304	Norman Wells - D	63,000	3.414	18,451	0.841	16
15	305	Tuktoyaktuk	4,584,515	3.697	1,240,016	1.001	1,241
16	306	Fort McPherson	3,422,267	3.609	948,301	0.926	878
17	307	Aklavik	2,776,285	3.475	798,914	0.914	730
18	308	Deline	2,658,924	3.546	749,826	1.015	761
19	309	Fort Good Hope	2,874,492	3.576	803,823	1.001	804
20	310	Tulita	2,200,488	3.634	605,551	0.905	548
21	311	Paulatuk	1,350,941	3.492	386,914	1.090	422
22	312	Sachs Harbour	907,022	3.189	284,401	1.075	306
23	313	Tsiigehtchic	864,359	3.537	244,353	0.985	241
24	314	Colville Lake	338,554	2.957	114,488	1.133	130
25	315	Ulukhaktok	1,986,962	3.616	549,489	1.111	610
26	**Subtotal - Diesel**		**44,310,582**	**3.603**	**12,337,411**	**0.931**	**11,491**

NATURAL GAS

Line No.	Plant No.		Generation (kWh)	Plant Efficiency (kWh/L)	Fuel Required (m^3)	Fuel Price (m^3)	Fuel Cost ($000's)
27	301	Inuvik	29,773,906	3.399	8,758,336	0.430	3,769
28	**Subtotal - Natural Gas**		**29,773,906**		**8,758,336**		**3,769**

PURCHASED POWER

Line No.	Plant No.		Generation (kWh)	Price ($/kWh)	Cost ($000's)
29	304	Norman Wells	9,305,234	0.279	2,593
30	**Subtotal - Purch. Power**		**9,305,234**	**0.279**	**2,593**

Northwest Territories Power Corporation
Summary of Generation, Sales, and Revenue
2006/07 and 2007/08
Lutsel K'e

Description	2006/07 Actual	2007/08 Actual
SALES AND REVENUE		
Residential		
Sales (MWh)	697	711
Customers	121	119
Average MWh Sales/Customer	5.76	5.97
Revenue (000s)	459	528
General Service		
Sales (MWh)	669	692
Customers	37	38
Average MWh Sales/Customer	18.08	18.21
Revenue (000s)	404	382
Streetlights		
Sales (MWh)	29	27
Revenue (000s)	30	30
Total Community		
Sales (MWh)	1,395	1,430
Customers	158	157
Revenue (000s)	893	940
GENERATION		
Source (MWh)		
Hydro		
Gas		
Cubic Metres (000s)		
Diesel	1,604	1,647
Litres (000s)	*441*	*476*
Purchased Power		
Total Generation	1,604	1,647
% of Total Generation		
Hydro		
Diesel	100%	100%
Purchased		

Appendix 2

LutselK'e HOMER model and diesel displacing energy

Lutsel K'e wind project calculation of net diesel displaced from HOMER model output									
Minimum diesel plant load 54kW (30% of 180kW smalest generator), wind speed 6.2 m/s									
		Losses from generation				Reductions in surplus			
Project configuration	HOMER generation kWh	Availability 95%	Electrical & other 10%	Net generation	HOMER surplus energy kWh	Availability	Electrical & other losses	Net surplus	Diesel displaced kWh
3 Wenvor 30 kW	190,205	9,510	19,021	161,674	3593	0	0	0	161,674
2 Endurance E3120	334,700	16,735	33,470	284,495	17,992	8,368	3,347	6,278	278,218
2 AOC 15/50	271,998	13,600	27,200	231,198	16,027	6,800	2,720	6,507	224,691
1 Northwind 100	245,367	12,268	24,537	208,562	6,733	0	0	0	208,562
Assumptions in reductions of surplus									
For 3 Wenvor 30s	1	The small amount of surplus energy would be consumed by electrical & other losses							
For 2 Endurance 3120s	1	One half of downtime is non-coincident making remaining generation all diesel displacing							
	2	One tenth of losses are systematic like electrical that occur during high output reducing surplus differentially							
For 2 AOC 15/50s	1	One half of downtime is non-coincident making remaining generation all diesel displacing							
	2	One tenth of losses are systematic like electrical that occur during high output reducing surplus differentially							
For 1 Northwind 100	1	The small amount of surplus energy would be consumed by electrical & other losses							

Appendix 3

Wind Project Capital Costs

Lutsel K'e Wind Project Capital Costs				
Site: high ridge south of the community				
	medium penetration	medium penetration	medium penetration	medium penetration
Cost category	**Three 30kW Wenvor turbines**	**Two E-3120 50kW turbines**	**Two Seaforth AOC 15/50 turbines**	**1 NPS NW 100kW turbine**
Project Design & Mgmt				
project design	$30,000	$30,000	$30,000	$30,000
environmental assessment & permitting	$15,000	$15,000	$15,000	$15,000
project management	$30,000	$40,000	$40,000	$40,000
Site Preparation				
road construction ($100,000 per km) 200m	$20,000	$20,000	$20,000	$20,000
road upgrading				
powerline construction 5.5km lump sum	$1,000,000	$1,000,000	$1,000,000	$1,000,000
powerline upgrading 1 to 3 ph				
Wind Equipment Purchase				
wind turbines + towers + SCADA	$360,000	$500,000	$350,000	$377,000
towers (if not included above)				
gin pole			$15,000	
winch equipment	$22,000			
shipping	$45,000	$50,000	$50,000	$50,000
shipping Hay River to Lutsel K'e	$15,000	$20,000	$20,000	$20,000
transformers	$25,000	$25,000	$25,000	$25,000
Installation				
geotehnical ($60k first + $10k for additional turbines)	$70,000	$70,000	$70,000	$60,000
foundtion design $50k first +$10k additional turbines	$60,000	$60,000	$60,000	$50,000
foundation installation	$100,000	$100,000	$100,000	$100,000
equipment rental	$40,000	$50,000	$50,000	$20,000
crane mob and demob NW100 only				$100,000
crane site work NW 100 only				$15,000
control buildings	$10,000	$10,000	$10,000	$10,000
utility interconnection	$20,000	$20,000	$20,000	$20,000
commissioning	$15,000	$20,000	$20,000	$20,000
labour - assembly & supervision	$30,000	$50,000	$50,000	$50,000
travel and accommodation	$30,000	$30,000	$30,000	$30,000
Diesel Plant Modifications				
high speed communications	$50,000	$50,000	$50,000	$50,000
dump load	$20,000	$20,000	$20,000	$20,000
plant modifications	$30,000	$30,000	$30,000	$30,000
Other				
initial spare parts	$5,000	$10,000	$10,000	$10,000
Insurance	$10,000	$10,000	$10,000	$15,000
other overhead costs (contracts etc)	$40,000	$40,000	$40,000	$50,000
SUBTOTAL CONSTRUCTION	**$2,092,000**	**$2,270,000**	**$2,135,000**	**$2,227,000**
Contingency 10%	**$209,200**	**$227,000**	**$213,500**	**$222,700**
TOTAL CONSTRUCTION	**$2,301,200**	**$2,497,000**	**$2,348,500**	**$2,449,700**
Owners Costs				
manage project organization	$25,000	$30,000	$30,000	$40,000
negotiate agreements	$30,000	$30,000	$30,000	$30,000
staff training	$35,000	$35,000	$35,000	$35,000
TOTAL OWNERS' COSTS	**$90,000**	**$95,000**	**$95,000**	**$105,000**
TOTAL PROJECT COST	**$2,391,200**	**$2,592,000**	**$2,443,500**	**$2,554,700**
Installed capacity kW	105	110	120	100
Installed cost per kW	**$22,773**	**$23,564**	**$20,363**	**$25,547**
Annual O&M costs	$25,000	$25,000	$25,000	$20,000

Appendix 4

Wind Project Capital Costs without power line

Lutsel K'e Wind Project Capital Costs				
Site: high ridge south of the community (no power line cost)				
	medium penetration	medium penetration	medium penetration	medium penetration
Cost category	**Three 30kW Wenvor turbines**	**Two E-3120 50kW turbines**	**Two Seaforth AOC 15/50 turbines**	**1 NPS NW 100kW turbine**
Project Design & Mgmt				
project design	$30,000	$30,000	$30,000	$30,000
environmental assessment & permitting	$15,000	$15,000	$15,000	$15,000
project management	$30,000	$40,000	$40,000	$40,000
Site Preparation				
road construction ($100,000 per km) 200m	$20,000	$20,000	$20,000	$20,000
road upgrading				
powerline construction 5.5km lump sum	$0	$0	$0	$0
powerline upgrading 1 to 3 ph				
Wind Equipment Purchase				
wind turbines + towers + SCADA	$360,000	$500,000	$350,000	$377,000
towers (if not included above)				
gin pole			$15,000	
winch equipment	$22,000			
shipping	$45,000	$50,000	$50,000	$50,000
shipping Hay River to Lutsel K'e	$15,000	$20,000	$20,000	$20,000
transformers	$25,000	$25,000	$25,000	$25,000
Installation				
geotehnical ($60k first + $10k for additional turbines)	$70,000	$70,000	$70,000	$60,000
foundtion design $50k first +$10k additional turbines	$60,000	$60,000	$60,000	$50,000
foundation installation	$100,000	$100,000	$100,000	$100,000
equipment rental	$40,000	$50,000	$50,000	$20,000
crane mob and demob NW100 only				$100,000
crane site work NW 100 only				$15,000
control buildings	$10,000	$10,000	$10,000	$10,000
utility interconnection	$20,000	$20,000	$20,000	$20,000
commissioning	$15,000	$20,000	$20,000	$20,000
labour - assembly & supervision	$30,000	$50,000	$50,000	$50,000
travel and accommodation	$30,000	$30,000	$30,000	$30,000
Diesel Plant Modifications				
high speed communications	$50,000	$50,000	$50,000	$50,000
dump load	$20,000	$20,000	$20,000	$20,000
plant modifications	$30,000	$30,000	$30,000	$30,000
Other				
initial spare parts	$5,000	$10,000	$10,000	$10,000
Insurance	$10,000	$10,000	$10,000	$15,000
other overhead costs (contracts etc)	$40,000	$40,000	$40,000	$50,000
SUBTOTAL CONSTRUCTION	**$1,092,000**	**$1,270,000**	**$1,135,000**	**$1,227,000**
Contingency 10%	**$109,200**	**$127,000**	**$113,500**	**$122,700**
TOTAL CONSTRUCTION	**$1,201,200**	**$1,397,000**	**$1,248,500**	**$1,349,700**
Owners Costs				
manage project organization	$25,000	$30,000	$30,000	$40,000
negotiate agreements	$30,000	$30,000	$30,000	$30,000
staff training	$35,000	$35,000	$35,000	$35,000
TOTAL OWNERS' COSTS	**$90,000**	**$95,000**	**$95,000**	**$105,000**
TOTAL PROJECT COST	**$1,291,200**	**$1,492,000**	**$1,343,500**	**$1,454,700**
Installed capacity kW	105	110	120	100
Installed cost per kW	**$12,297**	**$13,564**	**$11,196**	**$14,547**
Annual O&M costs	$25,000	$25,000	$25,000	$20,000

Appendix 5

3 Wenvor 30s economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e three Wenvor 30 wind turbines, with 5.5km power line											
Capital cost	$2,391,200		Capacity	105	kW	Fixed O&M	$25,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	161,674	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$2,391,200	$179,340	$119,560	$25,000	$0	$323,900	161,674	$2.003	$323,900	161,674	$2.003
2	$2,271,640	$170,373	$119,560	$25,500	$0	$315,433	161,674	$1.951	$299,295	153,402	$1.951
3	$2,152,080	$161,406	$119,560	$26,010	$0	$306,976	161,674	$1.899	$276,368	145,554	$1.899
4	$2,032,520	$152,439	$119,560	$26,530	$0	$298,529	161,674	$1.846	$255,013	138,107	$1.846
5	$1,912,960	$143,472	$119,560	$27,061	$0	$290,093	161,674	$1.794	$235,128	131,041	$1.794
6	$1,793,400	$134,505	$119,560	$27,602	$0	$281,667	161,674	$1.742	$216,618	124,337	$1.742
7	$1,673,840	$125,538	$119,560	$28,154	$0	$273,252	161,674	$1.690	$199,395	117,975	$1.690
8	$1,554,280	$116,571	$119,560	$28,717	$0	$264,848	161,674	$1.638	$183,374	111,939	$1.638
9	$1,434,720	$107,604	$119,560	$29,291	$0	$256,455	161,674	$1.586	$168,479	106,212	$1.586
10	$1,315,160	$98,637	$119,560	$29,877	$0	$248,074	161,674	$1.534	$154,635	100,778	$1.534
11	$1,195,600	$89,670	$119,560	$30,475	$0	$239,705	161,674	$1.483	$141,773	95,622	$1.483
12	$1,076,040	$80,703	$119,560	$31,084	$0	$231,347	161,674	$1.431	$129,829	90,730	$1.431
13	$956,480	$71,736	$119,560	$31,706	$0	$223,002	161,674	$1.379	$118,743	86,088	$1.379
14	$836,920	$62,769	$119,560	$32,340	$0	$214,669	161,674	$1.328	$108,458	81,683	$1.328
15	$717,360	$53,802	$119,560	$32,987	$0	$206,349	161,674	$1.276	$98,920	77,504	$1.276
16	$597,800	$44,835	$119,560	$33,647	$0	$198,042	161,674	$1.225	$90,081	73,539	$1.225
17	$478,240	$35,868	$119,560	$34,320	$0	$189,748	161,674	$1.174	$81,892	69,776	$1.174
18	$358,680	$26,901	$119,560	$35,006	$0	$181,467	161,674	$1.122	$74,312	66,206	$1.122
19	$239,120	$17,934	$119,560	$35,706	$0	$173,200	161,674	$1.071	$67,298	62,819	$1.071
20	$119,560	$8,967	$119,560	$36,420	$0	$164,947	161,674	$1.020	$60,812	59,605	$1.020
									$3,284,323	2,054,590	$1.599
Real levelized cost of energy					**$1.599**						

Appendix 5

2 Endurance E-3120s economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e two Endurance E3120 wind turbines, with 5.5km power line											
Capital cost	$2,592,000		Capacity	110	kW	Fixed O&M	$25,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	278,218	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$2,592,000	$194,400	$129,600	$25,000	$0	$349,000	278,218	$1.254	$349,000	278,218	$1.254
2	$2,462,400	$184,680	$129,600	$25,500	$0	$339,780	278,218	$1.221	$322,396	263,984	$1.221
3	$2,332,800	$174,960	$129,600	$26,010	$0	$330,570	278,218	$1.188	$297,610	250,477	$1.188
4	$2,203,200	$165,240	$129,600	$26,530	$0	$321,370	278,218	$1.155	$274,524	237,662	$1.155
5	$2,073,600	$155,520	$129,600	$27,061	$0	$312,181	278,218	$1.122	$253,031	225,503	$1.122
6	$1,944,000	$145,800	$129,600	$27,602	$0	$303,002	278,218	$1.089	$233,026	213,966	$1.089
7	$1,814,400	$136,080	$129,600	$28,154	$0	$293,834	278,218	$1.056	$214,414	203,018	$1.056
8	$1,684,800	$126,360	$129,600	$28,717	$0	$284,677	278,218	$1.023	$197,104	192,631	$1.023
9	$1,555,200	$116,640	$129,600	$29,291	$0	$275,531	278,218	$0.990	$181,011	182,776	$0.990
10	$1,425,600	$106,920	$129,600	$29,877	$0	$266,397	278,218	$0.958	$166,056	173,425	$0.958
11	$1,296,000	$97,200	$129,600	$30,475	$0	$257,275	278,218	$0.925	$152,165	164,552	$0.925
12	$1,166,400	$87,480	$129,600	$31,084	$0	$248,164	278,218	$0.892	$139,267	156,133	$0.892
13	$1,036,800	$77,760	$129,600	$31,706	$0	$239,066	278,218	$0.859	$127,297	148,145	$0.859
14	$907,200	$68,040	$129,600	$32,340	$0	$229,980	278,218	$0.827	$116,194	140,565	$0.827
15	$777,600	$58,320	$129,600	$32,987	$0	$220,907	278,218	$0.794	$105,899	133,373	$0.794
16	$648,000	$48,600	$129,600	$33,647	$0	$211,847	278,218	$0.761	$96,360	126,550	$0.761
17	$518,400	$38,880	$129,600	$34,320	$0	$202,800	278,218	$0.729	$87,525	120,075	$0.729
18	$388,800	$29,160	$129,600	$35,006	$0	$193,766	278,218	$0.696	$79,348	113,932	$0.696
19	$259,200	$19,440	$129,600	$35,706	$0	$184,746	278,218	$0.664	$71,784	108,103	$0.664
20	$129,600	$9,720	$129,600	$36,420	$0	$175,740	278,218	$0.632	$64,791	102,572	$0.632
									$3,528,801	3,535,658	$0.998
Real levelized cost of energy					**$0.998**						

Appendix 5

2 AOC 15/50s economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e two AOC 15/50 wind turbines with 5.5km power line											
Capital cost	$2,443,500		Capacity	120	kW	Fixed O&M	$25,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	224,691	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$2,443,500	$183,263	$122,175	$25,000	$0	$330,438	224,691	$1.471	$330,438	224,691	$1.471
2	$2,321,325	$174,099	$122,175	$25,500	$0	$321,774	224,691	$1.432	$305,312	213,195	$1.432
3	$2,199,150	$164,936	$122,175	$26,010	$0	$313,121	224,691	$1.394	$281,901	202,288	$1.394
4	$2,076,975	$155,773	$122,175	$26,530	$0	$304,478	224,691	$1.355	$260,095	191,938	$1.355
5	$1,954,800	$146,610	$122,175	$27,061	$0	$295,846	224,691	$1.317	$239,791	182,118	$1.317
6	$1,832,625	$137,447	$122,175	$27,602	$0	$287,224	224,691	$1.278	$220,892	172,800	$1.278
7	$1,710,450	$128,284	$122,175	$28,154	$0	$278,613	224,691	$1.240	$203,307	163,959	$1.240
8	$1,588,275	$119,121	$122,175	$28,717	$0	$270,013	224,691	$1.202	$186,950	155,571	$1.202
9	$1,466,100	$109,958	$122,175	$29,291	$0	$261,424	224,691	$1.163	$171,743	147,611	$1.163
10	$1,343,925	$100,794	$122,175	$29,877	$0	$252,847	224,691	$1.125	$157,610	140,059	$1.125
11	$1,221,750	$91,631	$122,175	$30,475	$0	$244,281	224,691	$1.087	$144,480	132,893	$1.087
12	$1,099,575	$82,468	$122,175	$31,084	$0	$235,727	224,691	$1.049	$132,288	126,094	$1.049
13	$977,400	$73,305	$122,175	$31,706	$0	$227,186	224,691	$1.011	$120,971	119,643	$1.011
14	$855,225	$64,142	$122,175	$32,340	$0	$218,657	224,691	$0.973	$110,473	113,521	$0.973
15	$733,050	$54,979	$122,175	$32,987	$0	$210,141	224,691	$0.935	$100,738	107,713	$0.935
16	$610,875	$45,816	$122,175	$33,647	$0	$201,637	224,691	$0.897	$91,716	102,202	$0.897
17	$488,700	$36,653	$122,175	$34,320	$0	$193,147	224,691	$0.860	$83,360	96,973	$0.860
18	$366,525	$27,489	$122,175	$35,006	$0	$184,670	224,691	$0.822	$75,623	92,012	$0.822
19	$244,350	$18,326	$122,175	$35,706	$0	$176,207	224,691	$0.784	$68,466	87,304	$0.784
20	$122,175	$9,163	$122,175	$36,420	$0	$167,758	224,691	$0.747	$61,848	82,838	$0.747
									$3,347,999	2,855,425	$1.173
Real levelized cost of energy					**$1.173**						

Appendix 5

1 Northwind 100 economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e one NorthWind 100 wind turbine with 5.5km power line											
Capital cost	$2,554,700		Capacity	100	kW	Fixed O&M	$20,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	208,562	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$2,554,700	$191,603	$127,735	$20,000	$0	$339,338	208,562	$1.627	$339,338	208,562	$1.627
2	$2,426,965	$182,022	$127,735	$20,400	$0	$330,157	208,562	$1.583	$313,266	197,891	$1.583
3	$2,299,230	$172,442	$127,735	$20,808	$0	$320,985	208,562	$1.539	$288,980	187,767	$1.539
4	$2,171,495	$162,862	$127,735	$21,224	$0	$311,821	208,562	$1.495	$266,367	178,160	$1.495
5	$2,043,760	$153,282	$127,735	$21,649	$0	$302,666	208,562	$1.451	$245,318	169,045	$1.451
6	$1,916,025	$143,702	$127,735	$22,082	$0	$293,518	208,562	$1.407	$225,732	160,396	$1.407
7	$1,788,290	$134,122	$127,735	$22,523	$0	$284,380	208,562	$1.364	$207,515	152,190	$1.364
8	$1,660,555	$124,542	$127,735	$22,974	$0	$275,250	208,562	$1.320	$190,577	144,403	$1.320
9	$1,532,820	$114,962	$127,735	$23,433	$0	$266,130	208,562	$1.276	$174,834	137,015	$1.276
10	$1,405,085	$105,381	$127,735	$23,902	$0	$257,018	208,562	$1.232	$160,210	130,005	$1.232
11	$1,277,350	$95,801	$127,735	$24,380	$0	$247,916	208,562	$1.189	$146,630	123,354	$1.189
12	$1,149,615	$86,221	$127,735	$24,867	$0	$238,824	208,562	$1.145	$134,025	117,043	$1.145
13	$1,021,880	$76,641	$127,735	$25,365	$0	$229,741	208,562	$1.102	$122,332	111,054	$1.102
14	$894,145	$67,061	$127,735	$25,872	$0	$220,668	208,562	$1.058	$111,489	105,373	$1.058
15	$766,410	$57,481	$127,735	$26,390	$0	$211,605	208,562	$1.015	$101,440	99,981	$1.015
16	$638,675	$47,901	$127,735	$26,917	$0	$202,553	208,562	$0.971	$92,133	94,866	$0.971
17	$510,940	$38,321	$127,735	$27,456	$0	$193,511	208,562	$0.928	$83,517	90,012	$0.928
18	$383,205	$28,740	$127,735	$28,005	$0	$184,480	208,562	$0.885	$75,546	85,407	$0.885
19	$255,470	$19,160	$127,735	$28,565	$0	$175,460	208,562	$0.841	$68,176	81,037	$0.841
20	$127,735	$9,580	$127,735	$29,136	$0	$166,451	208,562	$0.798	$61,366	76,891	$0.798
									$3,408,790	2,650,454	$1.286
Real levelized cost of energy					**$1.286**						

Appendix 5

3 Wenvor 30s no power line economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e three Wenvor 30 wind turbines no power line											
Capital cost	$1,291,200		Capacity	105	kW	Fixed O&M	$25,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	161,674	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$1,291,200	$96,840	$64,560	$25,000	$0	$186,400	161,674	$1.153	$186,400	161,674	$1.153
2	$1,226,640	$91,998	$64,560	$25,500	$0	$182,058	161,674	$1.126	$172,743	153,402	$1.126
3	$1,162,080	$87,156	$64,560	$26,010	$0	$177,726	161,674	$1.099	$160,005	145,554	$1.099
4	$1,097,520	$82,314	$64,560	$26,530	$0	$173,404	161,674	$1.073	$148,127	138,107	$1.073
5	$1,032,960	$77,472	$64,560	$27,061	$0	$169,093	161,674	$1.046	$137,054	131,041	$1.046
6	$968,400	$72,630	$64,560	$27,602	$0	$164,792	161,674	$1.019	$126,734	124,337	$1.019
7	$903,840	$67,788	$64,560	$28,154	$0	$160,502	161,674	$0.993	$117,120	117,975	$0.993
8	$839,280	$62,946	$64,560	$28,717	$0	$156,223	161,674	$0.966	$108,165	111,939	$0.966
9	$774,720	$58,104	$64,560	$29,291	$0	$151,955	161,674	$0.940	$99,827	106,212	$0.940
10	$710,160	$53,262	$64,560	$29,877	$0	$147,699	161,674	$0.914	$92,067	100,778	$0.914
11	$645,600	$48,420	$64,560	$30,475	$0	$143,455	161,674	$0.887	$84,846	95,622	$0.887
12	$581,040	$43,578	$64,560	$31,084	$0	$139,222	161,674	$0.861	$78,130	90,730	$0.861
13	$516,480	$38,736	$64,560	$31,706	$0	$135,002	161,674	$0.835	$71,885	86,088	$0.835
14	$451,920	$33,894	$64,560	$32,340	$0	$130,794	161,674	$0.809	$66,082	81,683	$0.809
15	$387,360	$29,052	$64,560	$32,987	$0	$126,599	161,674	$0.783	$60,690	77,504	$0.783
16	$322,800	$24,210	$64,560	$33,647	$0	$122,417	161,674	$0.757	$55,682	73,539	$0.757
17	$258,240	$19,368	$64,560	$34,320	$0	$118,248	161,674	$0.731	$51,034	69,776	$0.731
18	$193,680	$14,526	$64,560	$35,006	$0	$114,092	161,674	$0.706	$46,721	66,206	$0.706
19	$129,120	$9,684	$64,560	$35,706	$0	$109,950	161,674	$0.680	$42,722	62,819	$0.680
20	$64,560	$4,842	$64,560	$36,420	$0	$105,822	161,674	$0.655	$39,014	59,605	$0.655
									$1,945,050	2,054,590	$0.947
Real levelized cost of energy					**$0.947**						

Appendix 5

2 Endurance E-3120s no power line economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e two Endurance E3120 wind turbines, no power line											
Capital cost	$1,492,000		Capacity	110	kW	Fixed O&M	$25,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	278,218	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$1,492,000	$111,900	$74,600	$25,000	$0	$211,500	278,218	$0.760	$211,500	278,218	$0.760
2	$1,417,400	$106,305	$74,600	$25,500	$0	$206,405	278,218	$0.742	$195,845	263,984	$0.742
3	$1,342,800	$100,710	$74,600	$26,010	$0	$201,320	278,218	$0.724	$181,247	250,477	$0.724
4	$1,268,200	$95,115	$74,600	$26,530	$0	$196,245	278,218	$0.705	$167,639	237,662	$0.705
5	$1,193,600	$89,520	$74,600	$27,061	$0	$191,181	278,218	$0.687	$154,957	225,503	$0.687
6	$1,119,000	$83,925	$74,600	$27,602	$0	$186,127	278,218	$0.669	$143,142	213,966	$0.669
7	$1,044,400	$78,330	$74,600	$28,154	$0	$181,084	278,218	$0.651	$132,139	203,018	$0.651
8	$969,800	$72,735	$74,600	$28,717	$0	$176,052	278,218	$0.633	$121,894	192,631	$0.633
9	$895,200	$67,140	$74,600	$29,291	$0	$171,031	278,218	$0.615	$112,359	182,776	$0.615
10	$820,600	$61,545	$74,600	$29,877	$0	$166,022	278,218	$0.597	$103,488	173,425	$0.597
11	$746,000	$55,950	$74,600	$30,475	$0	$161,025	278,218	$0.579	$95,238	164,552	$0.579
12	$671,400	$50,355	$74,600	$31,084	$0	$156,039	278,218	$0.561	$87,567	156,133	$0.561
13	$596,800	$44,760	$74,600	$31,706	$0	$151,066	278,218	$0.543	$80,439	148,145	$0.543
14	$522,200	$39,165	$74,600	$32,340	$0	$146,105	278,218	$0.525	$73,817	140,565	$0.525
15	$447,600	$33,570	$74,600	$32,987	$0	$141,157	278,218	$0.507	$67,668	133,373	$0.507
16	$373,000	$27,975	$74,600	$33,647	$0	$136,222	278,218	$0.490	$61,962	126,550	$0.490
17	$298,400	$22,380	$74,600	$34,320	$0	$131,300	278,218	$0.472	$56,667	120,075	$0.472
18	$223,800	$16,785	$74,600	$35,006	$0	$126,391	278,218	$0.454	$51,758	113,932	$0.454
19	$149,200	$11,190	$74,600	$35,706	$0	$121,496	278,218	$0.437	$47,208	108,103	$0.437
20	$74,600	$5,595	$74,600	$36,420	$0	$116,615	278,218	$0.419	$42,993	102,572	$0.419
									$2,189,528	3,535,658	$0.619
Real levelized cost of energy					**$0.619**						

Appendix 5

2 AOC 15/50s no power line economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e two AOC 15/50 wind turbines, no power line											
Capital cost	$1,343,500		Capacity	120	kW	Fixed O&M	$25,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	224,691	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$1,343,500	$100,763	$67,175	$25,000	$0	$192,938	224,691	$0.859	$192,938	224,691	$0.859
2	$1,276,325	$95,724	$67,175	$25,500	$0	$188,399	224,691	$0.838	$178,760	213,195	$0.838
3	$1,209,150	$90,686	$67,175	$26,010	$0	$183,871	224,691	$0.818	$165,538	202,288	$0.818
4	$1,141,975	$85,648	$67,175	$26,530	$0	$179,353	224,691	$0.798	$153,209	191,938	$0.798
5	$1,074,800	$80,610	$67,175	$27,061	$0	$174,846	224,691	$0.778	$141,717	182,118	$0.778
6	$1,007,625	$75,572	$67,175	$27,602	$0	$170,349	224,691	$0.758	$131,008	172,800	$0.758
7	$940,450	$70,534	$67,175	$28,154	$0	$165,863	224,691	$0.738	$121,032	163,959	$0.738
8	$873,275	$65,496	$67,175	$28,717	$0	$161,388	224,691	$0.718	$111,741	155,571	$0.718
9	$806,100	$60,458	$67,175	$29,291	$0	$156,924	224,691	$0.698	$103,092	147,611	$0.698
10	$738,925	$55,419	$67,175	$29,877	$0	$152,472	224,691	$0.679	$95,042	140,059	$0.679
11	$671,750	$50,381	$67,175	$30,475	$0	$148,031	224,691	$0.659	$87,553	132,893	$0.659
12	$604,575	$45,343	$67,175	$31,084	$0	$143,602	224,691	$0.639	$80,588	126,094	$0.639
13	$537,400	$40,305	$67,175	$31,706	$0	$139,186	224,691	$0.619	$74,113	119,643	$0.619
14	$470,225	$35,267	$67,175	$32,340	$0	$134,782	224,691	$0.600	$68,096	113,521	$0.600
15	$403,050	$30,229	$67,175	$32,987	$0	$130,391	224,691	$0.580	$62,507	107,713	$0.580
16	$335,875	$25,191	$67,175	$33,647	$0	$126,012	224,691	$0.561	$57,318	102,202	$0.561
17	$268,700	$20,153	$67,175	$34,320	$0	$121,647	224,691	$0.541	$52,501	96,973	$0.541
18	$201,525	$15,114	$67,175	$35,006	$0	$117,295	224,691	$0.522	$48,033	92,012	$0.522
19	$134,350	$10,076	$67,175	$35,706	$0	$112,957	224,691	$0.503	$43,890	87,304	$0.503
20	$67,175	$5,038	$67,175	$36,420	$0	$108,633	224,691	$0.483	$40,050	82,838	$0.483
									$2,008,726	2,855,425	$0.703
Real levelized cost of energy					**$0.703**						

Appendix 5

1 Northwind 100 no power line economic model

Leading Edge Projects Generation LCOE Economic Model											
Project: Lutsel K'e one NorthWind 100 wind turbine, no power line											
Capital cost	$1,454,700		Capacity	100	kW	Fixed O&M	$20,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	208,562	kWh	Variable O&M		per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor					
Year	**Capital**	**Cost of Cap**	**Depreciation**	**Fixed O&M**	**Variable O&M**	**Total Ann cost**	**Ann energy**	**Cost per kWh**	**Discounted cost**	**Discounted energy**	**Discounted cost per kWh**
1	$1,454,700	$109,103	$72,735	$20,000	$0	$201,838	208,562	$0.968	$201,838	208,562	$0.968
2	$1,381,965	$103,647	$72,735	$20,400	$0	$196,782	208,562	$0.944	$186,714	197,891	$0.944
3	$1,309,230	$98,192	$72,735	$20,808	$0	$191,735	208,562	$0.919	$172,618	187,767	$0.919
4	$1,236,495	$92,737	$72,735	$21,224	$0	$186,696	208,562	$0.895	$159,482	178,160	$0.895
5	$1,163,760	$87,282	$72,735	$21,649	$0	$181,666	208,562	$0.871	$147,245	169,045	$0.871
6	$1,091,025	$81,827	$72,735	$22,082	$0	$176,643	208,562	$0.847	$135,849	160,396	$0.847
7	$1,018,290	$76,372	$72,735	$22,523	$0	$171,630	208,562	$0.823	$125,240	152,190	$0.823
8	$945,555	$70,917	$72,735	$22,974	$0	$166,625	208,562	$0.799	$115,367	144,403	$0.799
9	$872,820	$65,462	$72,735	$23,433	$0	$161,630	208,562	$0.775	$106,183	137,015	$0.775
10	$800,085	$60,006	$72,735	$23,902	$0	$156,643	208,562	$0.751	$97,642	130,005	$0.751
11	$727,350	$54,551	$72,735	$24,380	$0	$151,666	208,562	$0.727	$89,703	123,354	$0.727
12	$654,615	$49,096	$72,735	$24,867	$0	$146,699	208,562	$0.703	$82,326	117,043	$0.703
13	$581,880	$43,641	$72,735	$25,365	$0	$141,741	208,562	$0.680	$75,474	111,054	$0.680
14	$509,145	$38,186	$72,735	$25,872	$0	$136,793	208,562	$0.656	$69,112	105,373	$0.656
15	$436,410	$32,731	$72,735	$26,390	$0	$131,855	208,562	$0.632	$63,209	99,981	$0.632
16	$363,675	$27,276	$72,735	$26,917	$0	$126,928	208,562	$0.609	$57,734	94,866	$0.609
17	$290,940	$21,821	$72,735	$27,456	$0	$122,011	208,562	$0.585	$52,658	90,012	$0.585
18	$218,205	$16,365	$72,735	$28,005	$0	$117,105	208,562	$0.561	$47,955	85,407	$0.561
19	$145,470	$10,910	$72,735	$28,565	$0	$112,210	208,562	$0.538	$43,600	81,037	$0.538
20	$72,735	$5,455	$72,735	$29,136	$0	$107,326	208,562	$0.515	$39,568	76,891	$0.515
									$2,069,517	2,650,454	$0.781
Real levelized cost of energy					**$0.781**						

Appendix 6

Diesel fuel $1.00 per litre economic model

Leading Edge Projects Generation LCOE Economic Model

Project: Lutsel K'e incremental diesel generation, 3.8 kWh per litre, fuel at $1.00 per litre, fuel inflation at 3% per year, variable O&M $0.03 per kWh

Capital cost	$0		Capacity		kW	Fixed O&M	$3,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	100,000	kWh	Fuel	$0.263	per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor			Fuel inflation	3.00%	

Year	Capital	Cost of Cap	Depreciation	Fixed O&M	Fuel cost	Total Ann cost	Ann energy	Cost per kWh	Discounted cost	Discounted energy	Discounted cost per kWh
1	$0	$0	$0	$3,000	$26,300	$29,300	100,000	$0.293	$29,300	100,000	$0.293
2	$0	$0	$0	$3,060	$27,089	$30,149	100,000	$0.301	$28,606	94,884	$0.301
3	$0	$0	$0	$3,121	$27,902	$31,023	100,000	$0.310	$27,930	90,029	$0.310
4	$0	$0	$0	$3,184	$28,739	$31,922	100,000	$0.319	$27,269	85,423	$0.319
5	$0	$0	$0	$3,247	$29,601	$32,848	100,000	$0.328	$26,624	81,053	$0.328
6	$0	$0	$0	$3,312	$30,489	$33,801	100,000	$0.338	$25,995	76,906	$0.338
7	$0	$0	$0	$3,378	$31,404	$34,782	100,000	$0.348	$25,381	72,971	$0.348
8	$0	$0	$0	$3,446	$32,346	$35,792	100,000	$0.358	$24,781	69,238	$0.358
9	$0	$0	$0	$3,515	$33,316	$36,831	100,000	$0.368	$24,196	65,695	$0.368
10	$0	$0	$0	$3,585	$34,316	$37,901	100,000	$0.379	$23,625	62,334	$0.379
11	$0	$0	$0	$3,657	$35,345	$39,002	100,000	$0.390	$23,068	59,145	$0.390
12	$0	$0	$0	$3,730	$36,405	$40,135	100,000	$0.401	$22,524	56,119	$0.401
13	$0	$0	$0	$3,805	$37,498	$41,302	100,000	$0.413	$21,992	53,248	$0.413
14	$0	$0	$0	$3,881	$38,622	$42,503	100,000	$0.425	$21,474	50,523	$0.425
15	$0	$0	$0	$3,958	$39,781	$43,740	100,000	$0.437	$20,968	47,938	$0.437
16	$0	$0	$0	$4,038	$40,975	$45,012	100,000	$0.450	$20,474	45,486	$0.450
17	$0	$0	$0	$4,118	$42,204	$46,322	100,000	$0.463	$19,992	43,159	$0.463
18	$0	$0	$0	$4,201	$43,470	$47,671	100,000	$0.477	$19,521	40,950	$0.477
19	$0	$0	$0	$4,285	$44,774	$49,059	100,000	$0.491	$19,062	38,855	$0.491
20	$0	$0	$0	$4,370	$46,117	$50,488	100,000	$0.505	$18,613	36,867	$0.505
									$471,397	1,270,823	$0.371
Real levelized cost of energy					**$0.371**						

Appendix 6

Diesel fuel at $1.25 per litre economic model

Leading Edge Projects Generation LCOE Economic Model

Project: Lutsel K'e incremental diesel generation, 3.8 kWh per litre, fuel at $1.25 per litre, fuel inflation at 3% per year, variable O&M $0.03 per kWh

Capital cost	$0		Capacity		kW	Fixed O&M	$3,000	per year	Discount rate	5.39%	
Cost of capital	7.50%	Debt & equity	Annual Energy	100,000	kWh	Fuel	$0.329	per kWh			
Inflation	2.00%	per year	Project life	20	Years	Capacity factor			Fuel inflation	3.00%	

Year	Capital	Cost of Cap	Depreciation	Fixed O&M	Fuel cost	Total Ann cost	Ann energy	Cost per kWh	Discounted cost	Discounted energy	Discounted cost per kWh
1	$0	$0	$0	$3,000	$32,900	$35,900	100,000	$0.359	$35,900	100,000	$0.359
2	$0	$0	$0	$3,060	$33,887	$36,947	100,000	$0.369	$35,057	94,884	$0.369
3	$0	$0	$0	$3,121	$34,904	$38,025	100,000	$0.380	$34,233	90,029	$0.380
4	$0	$0	$0	$3,184	$35,951	$39,134	100,000	$0.391	$33,430	85,423	$0.391
5	$0	$0	$0	$3,247	$37,029	$40,277	100,000	$0.403	$32,645	81,053	$0.403
6	$0	$0	$0	$3,312	$38,140	$41,452	100,000	$0.415	$31,879	76,906	$0.415
7	$0	$0	$0	$3,378	$39,284	$42,663	100,000	$0.427	$31,131	72,971	$0.427
8	$0	$0	$0	$3,446	$40,463	$43,909	100,000	$0.439	$30,401	69,238	$0.439
9	$0	$0	$0	$3,515	$41,677	$45,192	100,000	$0.452	$29,689	65,695	$0.452
10	$0	$0	$0	$3,585	$42,927	$46,512	100,000	$0.465	$28,993	62,334	$0.465
11	$0	$0	$0	$3,657	$44,215	$47,872	100,000	$0.479	$28,314	59,145	$0.479
12	$0	$0	$0	$3,730	$45,541	$49,271	100,000	$0.493	$27,651	56,119	$0.493
13	$0	$0	$0	$3,805	$46,908	$50,712	100,000	$0.507	$27,003	53,248	$0.507
14	$0	$0	$0	$3,881	$48,315	$52,196	100,000	$0.522	$26,371	50,523	$0.522
15	$0	$0	$0	$3,958	$49,764	$53,723	100,000	$0.537	$25,754	47,938	$0.537
16	$0	$0	$0	$4,038	$51,257	$55,295	100,000	$0.553	$25,151	45,486	$0.553
17	$0	$0	$0	$4,118	$52,795	$56,913	100,000	$0.569	$24,563	43,159	$0.569
18	$0	$0	$0	$4,201	$54,379	$58,579	100,000	$0.586	$23,989	40,950	$0.586
19	$0	$0	$0	$4,285	$56,010	$60,295	100,000	$0.603	$23,428	38,855	$0.603
20	$0	$0	$0	$4,370	$57,690	$62,061	100,000	$0.621	$22,880	36,867	$0.621
									$578,462	1,270,823	$0.455
Real levelized cost of energy					**$0.455**						