



Natural Resources
Canada

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Canada

Canada

RETScreen® International

Clean Energy Project Analysis Software

Wind Energy Project Model

Click Here to Start

- Description & Flow Chart
- Colour Coding
- Online Manual

Worksheets

- Energy Model
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Features

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Clean Energy Decision Support Centre

www.retscreen.net


- Training & Support
- Internet Forums
- Marketplace
- Case Studies
- e-Textbook

Partners



Units: Metric

Site Conditions		Estimate	Notes/Range
Project name		Remote Community	See Online Manual
Project location		Yukon, Canada	
Wind data source		Wind speed	
Nearest location for weather data		Whitehorse A, YT	See Weather Database
Annual average wind speed	m/s	6.0	
Height of wind measurement	m	10.0	3.0 to 100.0 m
Wind shear exponent	-	0.15	0.10 to 0.40
Wind speed at 10 m	m/s	6.0	
Average atmospheric pressure	kPa	85.1	60.0 to 103.0 kPa
Annual average temperature	°C	-6	-20 to 30 °C

System Characteristics		Estimate	Notes/Range
Grid type	-	Isolated-grid	
Peak load	kW	78,000	
Wind turbine rated power	kW	150	 Complete Equipment Data sheet
Number of turbines	-	1	
Wind plant capacity	kW	150	
Hub height	m	30.0	6.0 to 100.0 m
Wind speed at hub height	m/s	7.1	
Wind penetration level	%	0.2%	
Suggested wind energy absorption rate	%	100%	
Wind energy absorption rate	%	100%	
Array losses	%	0%	0% to 20%
Airfoil soiling and/or icing losses	%	8%	1% to 10%
Other downtime losses	%	2%	2% to 7%
Miscellaneous losses	%	2%	2% to 6%

Annual Energy Production		Estimate Per Turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	150	150	
	MW	0.150	0.150	
Unadjusted energy production	MWh	585	585	
Pressure adjustment coefficient	-	0.84	0.84	0.59 to 1.02
Temperature adjustment coefficient	-	1.08	1.08	0.98 to 1.15
Gross energy production	MWh	530	530	
Losses coefficient	-	0.88	0.88	0.75 to 1.00
Specific yield	kWh/m²	819	819	150 to 1,500 kWh/m²
Wind plant capacity factor	%	36%	36%	20% to 40%
Renewable energy collected	MWh	469	469	
Renewable energy delivered	MWh	469	469	
	GJ	1,687	1,687	
Excess RE available	MWh	N/A	0	Complete Cost Analysis sheet

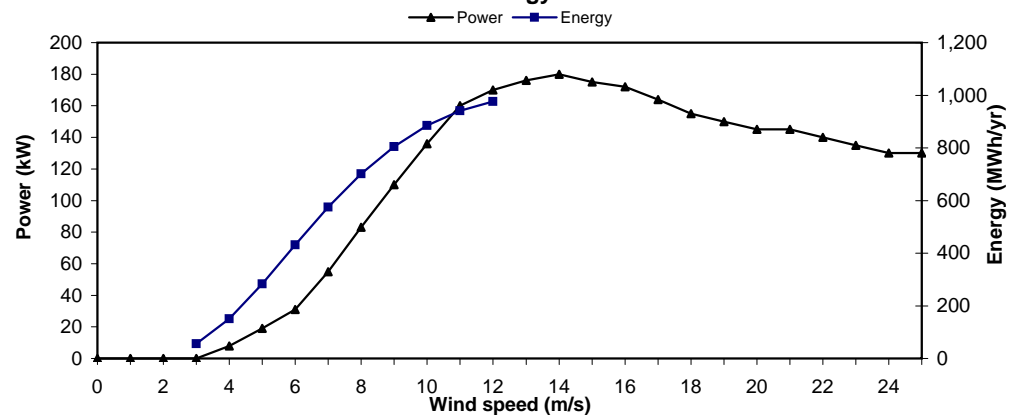
RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	150	See Product Database 6.0 to 100.0 m 7 to 80 m 35 to 5,027 m²
Hub height	m	30.0	
Rotor diameter	m	27	
Swept area	m²	572	
Wind turbine manufacturer		Nordex Balcke	Site specific
Wind turbine model		NORDEX N 27/150	
Energy curve data source	-	User-defined	

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	56.0
4	8.0	151.0
5	19.0	283.0
6	31.0	432.0
7	55.0	575.0
8	83.0	702.0
9	110.0	805.0
10	136.0	885.0
11	160.0	941.0
12	170.0	976.0
13	176.0	-
14	180.0	-
15	175.0	-
16	172.0	-
17	164.0	-
18	155.0	-
19	150.0	-
20	145.0	-
21	145.0	-
22	140.0	-
23	135.0	-
24	130.0	-
25	130.0	-

Power and Energy Curves



[Return to Energy Model sheet](#)

Type of project: **Custom**Currency: **\$**Cost references: **Canada - 2000**

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Site investigation	p-d	4.0	\$ 800	\$ 3,200		2.0 - 8.0	\$200 - \$800
Wind resource assessment	met tower	1	\$ 18,000	\$ 18,000			\$10K - \$25K
Environmental assessment	p-d	4.0	\$ 800	\$ 3,200		1.0 - 8.0	\$200 - \$800
Preliminary design	p-d	4.0	\$ 800	\$ 3,200		2.0 - 20.0	\$200 - \$800
Detailed cost estimate	p-d	8.0	\$ 800	\$ 6,400		3.0 - 20.0	\$200 - \$800
GHG baseline study and MP	project		\$ -	\$ -			\$40K - \$60K
Report preparation	p-d	4.0	\$ 800	\$ 3,200		2.0 - 15.0	\$200 - \$800
Project management	p-d	4.0	\$ 800	\$ 3,200		2.0 - 11.0	\$300 - \$800
Travel and accommodation	p-trip	2	\$ 300	\$ 600			
Other - Feasibility study	Cost	1	\$ 2,500	\$ 2,500			
Sub-total:				\$ 43,500	5.0%		
Development							
PPA negotiation	p-d	2.0	\$ 800	\$ 1,600		0.0 - 30.0	\$300 - \$1,500
Permits and approvals	p-d	8.0	\$ 800	\$ 6,400		0.0 - 400.0	\$200 - \$800
Land rights	project	1	\$ 5,000	\$ 5,000			
Land survey	p-d	2.0	\$ 600	\$ 1,200		0.0 - 100.0	\$400 - \$600
GHG validation and registration	project		\$ -	\$ -			\$40K - \$100K
Project financing	p-d	6.0	\$ 1,500	\$ 9,000		3.0 - 100.0	\$500 - \$1,500
Legal and accounting	p-d	6.0	\$ 1,200	\$ 7,200		3.0 - 100.0	\$300 - \$1,500
Project management	p-yr	0.05	\$ 130,000	\$ 6,500		0.20 - 4.00	\$130K - \$180K
Travel and accommodation	p-trip	2	\$ 300	\$ 600			
Other - Development	Cost	1	\$ 2,500	\$ 2,500			
Sub-total:				\$ 40,000	4.6%		
Engineering							
Wind turbine(s) micro-siting	p-d	6.0	\$ 800	\$ 4,800		0.0 - 300.0	\$200 - \$800
Mechanical design	p-d		\$ -	\$ -		2.0 - 150.0	\$200 - \$800
Electrical design	p-d	10.0	\$ 800	\$ 8,000		3.0 - 300.0	\$200 - \$800
Civil design	p-d	10.0	\$ 800	\$ 8,000		3.0 - 300.0	\$200 - \$800
Tenders and contracting	p-d	10.0	\$ 800	\$ 8,000		4.0 - 300.0	\$200 - \$800
Construction supervision	p-yr	0.20	\$ 130,000	\$ 26,000		0.00 - 2.00	\$130K - \$180K
Other - Engineering	Cost	2	\$ 2,500	\$ 5,000			
Sub-total:				\$ 59,800	6.9%		
Energy Equipment							
Wind turbine(s)	kW	150	\$ 1,500	\$ 225,000			\$1,000 - 3,000
Spare parts	%	3.0%	\$ 225,000	\$ 6,750		0.0% - 30.0%	
Transportation	turbine	1	\$ 75,000	\$ 75,000			
Other - Energy equipment	Cost	1	\$ 25,000	\$ 25,000			
Sub-total:				\$ 331,750	38.4%		
Balance of Plant							
Wind turbine(s) foundation(s)	turbine	1	\$ 50,000	\$ 50,000			
Wind turbine(s) erection	turbine	1	\$ 50,000	\$ 50,000			
Road construction	km	6.00	\$ 5,000	\$ 30,000			\$0K - \$80K/km
Transmission line	km	2.00	\$ 50,000	\$ 100,000			
Substation	project	1	\$ 50,000	\$ 50,000			
Control and O&M building(s)	building	1	\$ 10,000	\$ 10,000		0 - 2	
Transportation	project	1	\$ 20,000	\$ 20,000			
Other - Balance of plant	Cost	1	\$ 5,000	\$ 5,000			
Sub-total:				\$ 315,000	36.5%		
Miscellaneous							
Training	p-d	10.0	\$ 800	\$ 8,000			\$200 - \$800
Commissioning	p-d	20.0	\$ 800	\$ 16,000			\$200 - \$800
Contingencies	%	3%	\$ 814,050	\$ 24,422		5% - 40%	
Interest during construction	6.0%	12 month(s)	\$ 838,472	\$ 25,154		3.0% - 15.0%	
Sub-total:				\$ 73,576	8.5%		
Initial Costs - Total				\$ 863,626	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Land lease	project	1	\$ 465	\$ 465			
Property taxes	project		\$ -	\$ -			
Insurance premium	project	1	\$ 2,300	\$ 2,300			
Transmission line maintenance	%	8.0%	\$ 150,000	\$ 12,000		3.0% - 6.0%	
Parts and labour	kWh	468,528	\$ 0.015	\$ 7,028			\$0.007 - \$0.024
GHG monitoring and verification	project		\$ -	\$ -			
Community benefits	-		\$ -	\$ -			
Travel and accommodation	p-trip	4	\$ 300	\$ 1,200			
General and administrative	%	8%	\$ 22,993	\$ 1,839		1% - 20%	
Contingencies	%	5%	\$ 24,832	\$ 1,242		10% - 20%	
Annual Costs - Total				\$ 26,074	100.0%		

Periodic Costs (Credits)	Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Major Component Replacement	Cost	10 yr	\$ 170,000		
			\$ -		
			\$ -		
End of project life		-	\$ -		

[Go to GHG Analysis sheet](#)

RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Wind Energy Project

Use GHG analysis sheet?
 Potential CDM project?

Type of analysis:

Background Information

Project Information			Global Warming Potential of GHG		
Project name	Remote Community	Project capacity	0.15 MW	21 tonnes CO ₂ = 1 tonne CH ₄	(IPCC 1996)
Project location	Yukon, Canada	Grid type	Isolated-grid	310 tonnes CO ₂ = 1 tonne N ₂ O	(IPCC 1996)

Base Case Electricity System (Baseline)

Fuel type	Fuel mix (%)	CO ₂ emission factor (kg/GJ)	CH ₄ emission factor (kg/GJ)	N ₂ O emission factor (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission factor (tCO ₂ /MWh)
Diesel (#2 oil)	50.0%	74.1	0.0020	0.0020	30.0%	5.0%	0.944
Small hydro	50.0%	0.0	0.0000	0.0000	100.0%	5.0%	0.000
Electricity mix	100%	130.0	0.0035	0.0035		5.0%	0.472

Does baseline change during project life?

Proposed Case Electricity System (Wind Energy Project)

Fuel type	Fuel mix (%)	CO ₂ emission factor (kg/GJ)	CH ₄ emission factor (kg/GJ)	N ₂ O emission factor (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission factor (tCO ₂ /MWh)
Electricity system							
Wind	100.0%	0.0	0.0000	0.0000	100.0%	5.0%	0.000

GHG Emission Reduction Summary

Electricity system	Base case GHG emission factor (tCO ₂ /MWh)	Proposed case GHG emission factor (tCO ₂ /MWh)	End-use annual energy delivered (MWh)	Gross annual GHG emission reduction (tCO ₂)	GHG credits transaction fee (%)	Net annual GHG emission reduction (tCO ₂)
	0.472	0.000	445	210	0.0%	210

[Complete Financial Summary sheet](#)

RETScreen® Financial Summary - Wind Energy Project
Annual Energy Balance

Project name	Remote Community	Peak load	kW	78,000
Project location	Yukon, Canada			
Renewable energy delivered	MWh	469	Net GHG reduction	t _{CO2} /yr
Excess RE available	MWh	-		210
Firm RE capacity	kW	-		
Grid type	Isolated-grid	Net GHG emission reduction - 25 yrs	t _{CO2}	5,254

Financial Parameters

Avoided cost of energy	\$/kWh	0.1000	Debt ratio	%	60.0%
RE production credit	\$/kWh	-	Debt interest rate	%	8.0%
			Debt term	yr	20
GHG emission reduction credit	\$/t _{CO2}	-	Income tax analysis?	yes/no	No
Energy cost escalation rate	%	2.5%			
Inflation	%	2.5%			
Discount rate	%	8.0%			
Project life	yr	25			

Project Costs and Savings

Initial Costs				Annual Costs and Debt	
Feasibility study	5.0%	\$	43,500	O&M	\$
Development	4.6%	\$	40,000		26,074
Engineering	6.9%	\$	59,800	Debt payments - 20 yrs	\$
Energy equipment	38.4%	\$	331,750		52,777
Balance of plant	36.5%	\$	315,000	Annual Costs and Debt - Total	\$
Miscellaneous	8.5%	\$	73,576		78,851
Initial Costs - Total	100.0%	\$	863,626	Annual Savings or Income	
				Energy savings/income	\$
Incentives/Grants		\$	-	Capacity savings/income	\$
					-
				Annual Savings - Total	\$
					46,853
Periodic Costs (Credits)					
Major Component Replacement		\$	170,000	Schedule yr # 10,20	
		\$	-		
		\$	-		
End of project life -		\$	-		

Financial Feasibility

Pre-tax IRR and ROI	%	#DIV/0!	Calculate energy production cost?	yes/no	No
After-tax IRR and ROI	%	#DIV/0!	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	41.6			
Year-to-positive cash flow	yr	more than 25	Project equity	\$	345,450
Net Present Value - NPV	\$	(741,777)	Project debt	\$	518,175
Annual Life Cycle Savings	\$	(69,489)	Debt payments	\$/yr	52,777
Benefit-Cost (B-C) ratio	-	(1.15)	Debt service coverage	-	(4.63)

Yearly Cash Flows

Year #	Pre-tax \$	After-tax \$	Cumulative \$
0	(345,450)	(345,450)	(345,450)
1	(31,479)	(31,479)	(376,929)
2	(30,947)	(30,947)	(407,876)
3	(30,401)	(30,401)	(438,277)
4	(29,841)	(29,841)	(468,118)
5	(29,268)	(29,268)	(497,386)
6	(28,680)	(28,680)	(526,066)
7	(28,078)	(28,078)	(554,144)
8	(27,460)	(27,460)	(581,604)
9	(26,827)	(26,827)	(608,432)
10	(243,793)	(243,793)	(852,225)
11	(25,514)	(25,514)	(877,739)
12	(24,832)	(24,832)	(902,571)
13	(24,133)	(24,133)	(926,704)
14	(23,417)	(23,417)	(950,122)
15	(22,683)	(22,683)	(972,805)
16	(21,931)	(21,931)	(994,736)
17	(21,160)	(21,160)	(1,015,896)
18	(20,369)	(20,369)	(1,036,265)
19	(19,559)	(19,559)	(1,055,825)
20	(297,294)	(297,294)	(1,353,118)
21	34,900	34,900	(1,318,219)
22	35,772	35,772	(1,282,446)
23	36,667	36,667	(1,245,780)
24	37,583	37,583	(1,208,197)
25	38,523	38,523	(1,169,674)

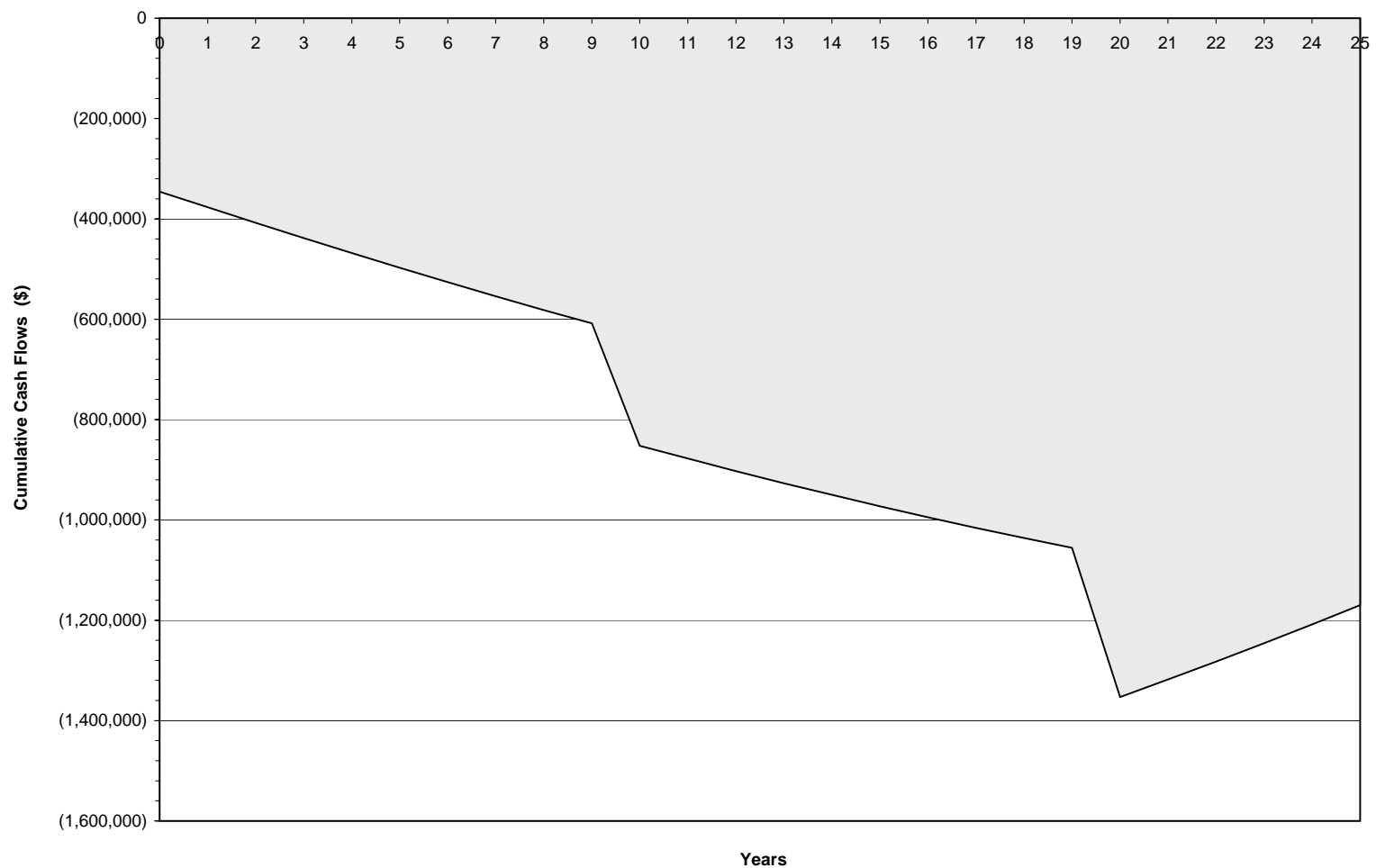
Cumulative Cash Flows Graph

Wind Energy Project Cumulative Cash Flows Remote Community, Yukon, Canada

Renewable energy delivered (MWh/yr): 469

Total Initial Costs: \$ 863,626

Net average GHG reduction (tCO₂/yr): 210



Year-to-positive cash flow: more than 25 yr

Net Present Value: \$ -741,777

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Use sensitivity analysis sheet?

Yes

Perform risk analysis too?

Yes

Project name

Remote Community

Project location

Yukon, Canada

Perform analysis on

Sensitivity range

Threshold

Net Present Value - NPV

20%

0

\$

Sensitivity Analysis for Net Present Value - NPV

		Avoided cost of energy (\$/kWh)				
RE delivered (MWh)		0.0800 -20%	0.0900 -10%	0.1000 0%	0.1100 10%	0.1200 20%
375	-20%	-971,022	-920,079	-869,135	-818,192	-767,249
422	-10%	-920,079	-862,767	-805,456	-748,145	-690,834
469	0%	-869,135	-805,456	-741,777	-678,098	-614,419
515	10%	-818,192	-748,145	-678,098	-608,051	-538,004
562	20%	-767,249	-690,834	-614,419	-538,004	-461,589

		Avoided cost of energy (\$/kWh)				
Initial costs (\$)		0.0800 -20%	0.0900 -10%	0.1000 0%	0.1100 10%	0.1200 20%
690,901	-20%	-696,410	-632,731	-569,052	-505,373	-441,694
777,263	-10%	-782,773	-719,094	-655,415	-591,735	-528,056
863,626	0%	-869,135	-805,456	-741,777	-678,098	-614,419
949,988	10%	-955,498	-891,819	-828,140	-764,460	-700,781
1,036,351	20%	-1,041,861	-978,181	-914,502	-850,823	-787,144

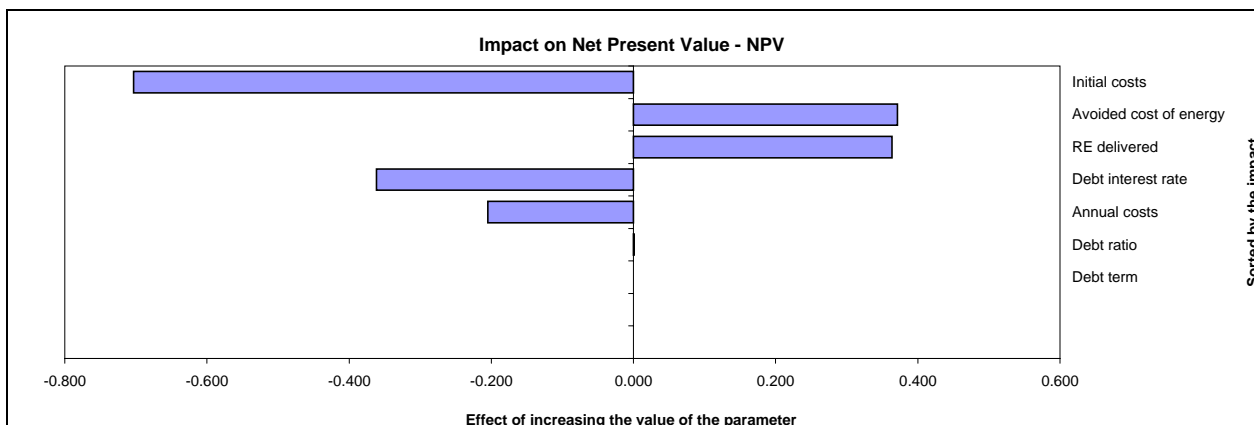
		Avoided cost of energy (\$/kWh)				
Annual costs (\$)		0.0800 -20%	0.0900 -10%	0.1000 0%	0.1100 10%	0.1200 20%
20,859	-20%	-798,259	-734,580	-670,901	-607,222	-543,543
23,467	-10%	-833,697	-770,018	-706,339	-642,660	-578,981
26,074	0%	-869,135	-805,456	-741,777	-678,098	-614,419
28,681	10%	-904,573	-840,894	-777,215	-713,536	-649,857
31,289	20%	-940,011	-876,332	-812,653	-748,974	-685,295

		Debt ratio (%)				
Debt interest rate (%)		48.0% -20%	54.0% -10%	60.0% 0%	66.0% 10%	72.0% 20%
6.4%	-20%	-693,688	-687,677	-681,666	-675,655	-669,644
7.2%	-10%	-717,410	-714,364	-711,318	-708,272	-705,226
8.0%	0%	-741,777	-741,777	-741,777	-741,777	-741,777
8.8%	10%	-766,756	-769,879	-773,001	-776,124	-779,246
9.6%	20%	-792,314	-798,631	-804,948	-811,266	-817,583

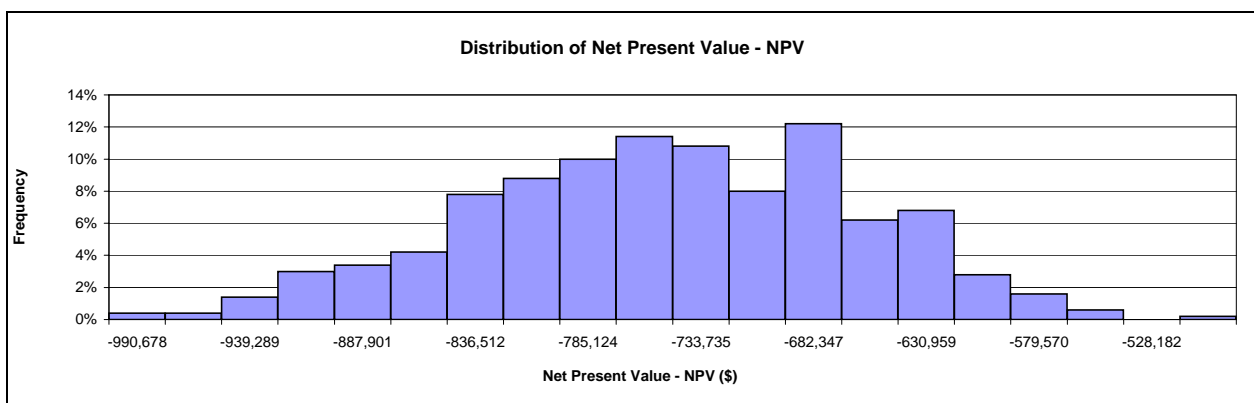
		Debt term (yr)				
Debt interest rate (%)		16.0 -20%	18.0 -10%	20.0 0%	22.0 10%	24.0 20%
6.4%	-20%	-690,000	-685,678	-681,666	-677,948	-674,508
7.2%	-10%	-715,578	-713,368	-711,318	-709,419	-707,664
8.0%	0%	-741,777	-741,777	-741,777	-741,777	-741,777
8.8%	10%	-768,575	-770,872	-773,001	-774,969	-776,783
9.6%	20%	-795,947	-800,620	-804,948	-808,943	-812,617

Risk Analysis for Net Present Value - NPV

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Avoided cost of energy	\$/kWh	0.1000	15%	0.0850	0.1150
RE delivered	MWh	469	15%	398	539
Initial costs	\$	863,626	20%	690,901	1,036,351
Annual costs	\$	26,074	15%	22,163	29,985
Debt ratio	%	60.0%	5%	57.0%	63.0%
Debt interest rate	%	8.0%	30%	5.6%	10.4%
Debt term	yr	20	0%	20	20



Median	\$	-749,025
Level of risk	%	10%
Minimum within level of confidence	\$	-903,677
Maximum within level of confidence	\$	-616,716



Minimum	Median	Maximum
5.0%	Level of confidence = 90%	5.0%
\$ -903,677	\$ -749,025	\$ -616,716

- This is clearly a research and demonstration project. It is not financially viable without consideration of the valuable information and experience gained during planning, installing, operating, monitoring and reporting. The high losses due to icing and remote grid failure detract from the financial viability of the project, but the critical factors are the high capital costs: installation, foundations, transportation, and maintenance.
- If this project is followed up with additional installations, and uses the knowledge gained from this project to enhance future ones, it should be possible to considerably improve the financial viability of wind energy in this particular community.
- In order to accurately calculate the energy produced by the wind turbine, the effect of the difference in altitude between the weather station and the site needs to be accounted for:
 - The temperature falls by roughly 6.5 °C for every 1,000 m increase in altitude;
 - The atmospheric pressure falls with increasing altitude. Up to about 5,000 m altitude, the mean atmospheric pressure, P , at an altitude of z meters above sea level can be estimated by:

$$P = P_{sealevel} e^{\frac{-z}{8200}}$$

where $P_{sealevel}$ is the atmospheric pressure at sea level (i.e., 101.33 kPa).

- For a single turbine with a distribution line nearby, no substation is required — the turbine transformer is specified to match the distribution line voltage.
- It can be expected that major components such as the blades or the drivetrain will eventually fail and require replacement. A set of blades or a drivetrain costs roughly 20% to 25% of the purchase price of the turbine. This is accounted for as a periodic cost. Due to the research & development nature of this project and the harsh environment in which this turbine is installed, this periodic cost is incurred every 10 years — more frequently than normal.
- Because of the small size of the project (150 kW) relative to the grid peak load of 78,000 kW, it is assumed that all of the energy produced by the wind turbine will be used by the grid.