



Natural Resources
Canada

Ressources naturelles
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
- Equipment Data
- Cost Analysis
- Greenhouse Gas Analysis
- Financial Summary

Features

- Product Data
- Weather Data
- Cost Data
- Unit Options
- Currency Options
- CDM / JI Project Analysis
- Sensitivity Analysis



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		Green Power Production	See Online Manual
Project location		Alberta, Canada	
Wind data source		Wind speed	
Nearest location for weather data		Lethbridge A, AB	See Weather Database
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	10.0	3.0 to 100.0 m
Wind shear exponent	-	0.17	0.10 to 0.40
Wind speed at 10 m	m/s	6.2	
Average atmospheric pressure	kPa	90.7	60.0 to 103.0 kPa
Annual average temperature	°C	6	-20 to 30 °C

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	600	 Complete Equipment Data sheet
Number of turbines	-	1	
Wind plant capacity	kW	600	
Hub height	m	40.0	6.0 to 100.0 m
Wind speed at hub height	m/s	7.8	
Array losses	%	0%	0% to 20%
Airfoil soiling and/or icing losses	%	1%	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	600	600	
	MW	0,600	0,600	
Unadjusted energy production	MWh	1,933	1,933	
Pressure adjustment coefficient	-	0.90	0.90	0.59 to 1.02
Temperature adjustment coefficient	-	1.03	1.03	0.98 to 1.15
Gross energy production	MWh	1,792	1,792	
Losses coefficient	-	0.95	0.95	0.75 to 1.00
Specific yield	kWh/m²	1,120	1,120	150 to 1,500 kWh/m²
Wind plant capacity factor	%	32%	32%	20% to 40%
Renewable energy delivered	MWh	1,704	1,704	
	GJ	6,134	6,134	Complete Cost Analysis sheet

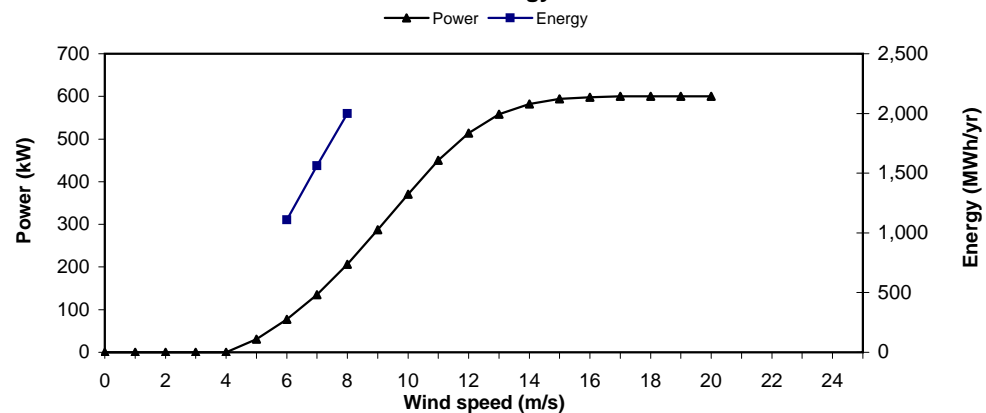
RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	600	See Product Database 6.0 to 100.0 m 7 to 80 m 35 to 5,027 m²
Hub height	m	40.0	
Rotor diameter	m	44	
Swept area	m²	1,521	
Wind turbine manufacturer		Vestas Wind Systems	Site specific
Wind turbine model		VESTAS V44/600kW	
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	-
4	0.0	-
5	30.4	-
6	77.3	1,108.0
7	135.0	1,562.0
8	206.0	2,000.0
9	287.0	-
10	371.0	-
11	450.0	-
12	514.0	-
13	558.0	-
14	582.0	-
15	594.0	-
16	598.0	-
17	600.0	-
18	600.0	-
19	600.0	-
20	600.0	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-

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	3.0	\$ 800	\$ 2,400		2.0 - 8.0	\$200 - \$800
Wind resource assessment	met tower	1	\$ 18,000	\$ 18,000			\$10K - \$25K
Environmental assessment	p-d	5.0	\$ 800	\$ 4,000		1.0 - 8.0	\$200 - \$800
Preliminary design	p-d	2.0	\$ 800	\$ 1,600		2.0 - 20.0	\$200 - \$800
Detailed cost estimate	p-d	4.0	\$ 800	\$ 3,200		3.0 - 20.0	\$200 - \$800
GHG baseline study and MP	project		\$ -	\$ -			\$40K - \$60K
Report preparation	p-d	1.0	\$ 800	\$ 800		2.0 - 15.0	\$200 - \$800
Project management	p-d	2.0	\$ 800	\$ 1,600		2.0 - 11.0	\$300 - \$800
Travel and accommodation	p-trip	4	\$ 300	\$ 1,200			
Other - Feasibility study	Cost	1	\$ 2,500	\$ 2,500			
Sub-total:				\$ 35,300	2.9%		
Development							
PPA negotiation	p-d	1.0	\$ 800	\$ 800		0.0 - 30.0	\$300 - \$1,500
Permits and approvals	p-d	3.0	\$ 800	\$ 2,400		0.0 - 400.0	\$200 - \$800
Land rights	project	1	\$ 5,000	\$ 5,000			
Land survey	p-d	4.0	\$ 600	\$ 2,400		0.0 - 100.0	\$400 - \$600
GHG validation and registration	project		\$ -	\$ -			\$40K - \$100K
Project financing	p-d	10.0	\$ 1,500	\$ 15,000		3.0 - 100.0	\$500 - \$1,500
Legal and accounting	p-d	10.0	\$ 1,200	\$ 12,000		3.0 - 100.0	\$300 - \$1,500
Project management	p-yr	0.10	\$ 130,000	\$ 13,000		0.20 - 4.00	\$130K - \$180K
Travel and accommodation	p-trip	6	\$ 300	\$ 1,800			
Other - Development	Cost	1	\$ 2,500	\$ 2,500			
Sub-total:				\$ 54,900	4.5%		
Engineering							
Wind turbine(s) micro-siting	p-d	1.0	\$ 800	\$ 800		0.0 - 300.0	\$200 - \$800
Mechanical design	p-d	1.0	\$ 800	\$ 800		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	5.0	\$ 800	\$ 4,000		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	\$ 3,500	\$ 7,000			
Sub-total:				\$ 54,600	4.5%		
Energy Equipment							
Wind turbine(s)	kW	600	\$ 1,200	\$ 720,000			\$1,000 - 3,000
Spare parts	%	1.0%	\$ 720,000	\$ 7,200		0.0% - 30.0%	
Transportation	turbine	1	\$ 50,000	\$ 50,000			
Other - Energy equipment	Cost	1	\$ 5,000	\$ 5,000			
Sub-total:				\$ 782,200	63.9%		
Balance of Plant							
Wind turbine(s) foundation(s)	turbine	1	\$ 60,000	\$ 60,000			
Wind turbine(s) erection	turbine	1	\$ 75,000	\$ 75,000			
Road construction	km		\$ -	\$ -			\$0K - \$80K/km
Transmission line	km	4.00	\$ 12,500	\$ 50,000			
Substation	project		\$ -	\$ -			
Control and O&M building(s)	building	1	\$ 5,000	\$ 5,000		0 - 2	
Transportation	project	1	\$ 5,000	\$ 5,000			
Other - Balance of plant	Cost	1	\$ 5,000	\$ 5,000			
Sub-total:				\$ 200,000	16.3%		
Miscellaneous							
Training	p-d	4.0	\$ 800	\$ 3,200			\$200 - \$800
Commissioning	p-d	4.0	\$ 800	\$ 3,200			\$200 - \$800
Contingencies	%	3%	\$ 1,133,400	\$ 34,002		5% - 40%	
Interest during construction	9.6%	12 month(s)	\$ 1,167,402	\$ 56,035		3.0% - 15.0%	
Sub-total:				\$ 96,437	7.9%		
Initial Costs - Total				\$ 1,223,437	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Land lease	project	1	\$ 1,300	\$ 1,300			
Property taxes	project	1	\$ 3,000	\$ 3,000			
Insurance premium	project	1	\$ 12,950	\$ 12,950			
Transmission line maintenance	%	3.0%	\$ 50,000	\$ 1,500		3.0% - 6.0%	
Parts and labour	kWh	1,703,977	\$ 0.010	\$ 17,040			\$0.007 - \$0.024
GHG monitoring and verification	project		\$ -	\$ -			
Community benefits	-		\$ -	\$ -			
Travel and accommodation	p-trip	12	\$ 300	\$ 3,600			
General and administrative	%	10%	\$ 39,390	\$ 3,939		1% - 20%	
Contingencies	%	10%	\$ 43,329	\$ 4,333		10% - 20%	
Annual Costs - Total				\$ 47,662	100.0%		

Periodic Costs (Credits)	Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Major Component Repair	Cost	15 yr	\$ 150,000		
			\$ -		
			\$ -		
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	Green Power Production	Project capacity	0.60 MW	21 tonnes CO ₂ = 1 tonne CH ₄	(IPCC 1996)
Project location	Alberta, Canada	Grid type	Central-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)
Natural gas	100.0%	56.1	0.0030	0.0010	45.0%	8.0%	0.491
Electricity mix	100%	135.5	0.0072	0.0024		8.0%	0.491

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%	8.0%	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)
	0.491	0.000	1,568	770	0.0%	770

[Complete Financial Summary sheet](#)

RETScreen® Financial Summary - Wind Energy Project
Annual Energy Balance

Project name	Green Power Production				
Project location	Alberta, Canada				
Renewable energy delivered	MWh	1,704	Net GHG reduction	t _{CO2} /yr	770
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type	Central-grid		Net GHG emission reduction - 25 yrs	t _{CO2}	19,246

Financial Parameters

Avoided cost of energy	\$/kWh	0.0800	Debt ratio	%	60.0%
RE production credit	\$/kWh	-	Debt interest rate	%	8.5%
			Debt term	yr	10
GHG emission reduction credit	\$/t _{CO2}	-	Income tax analysis?	yes/no	Yes
			Effective income tax rate	%	28.0%
			Loss carryforward?	yes/no	Flow-through
			Depreciation method	-	Declining balance
			Depreciation tax basis	%	0.0%
			Depreciation rate	%	30.0%
Energy cost escalation rate	%	3.0%	Tax holiday available?	yes/no	No
Inflation	%	2.5%			
Discount rate	%	9.0%			
Project life	yr	25			

Project Costs and Savings

Initial Costs			Annual Costs and Debt		
Feasibility study	2.9%	\$ 35,300	O&M	\$	47,662
Development	4.5%	\$ 54,900			
Engineering	4.5%	\$ 54,600	Debt payments - 10 yrs	\$	111,877
Energy equipment	63.9%	\$ 782,200	Annual Costs and Debt - Total	\$	159,538
Balance of plant	16.3%	\$ 200,000			
Miscellaneous	7.9%	\$ 96,437	Annual Savings or Income		
Initial Costs - Total	100.0%	\$ 1,223,437	Energy savings/income	\$	136,318
			Capacity savings/income	\$	-
Incentives/Grants	\$	-	Annual Savings - Total	\$	136,318
Periodic Costs (Credits)			Schedule yr # 15		
Major Component Repair	\$	150,000			
	\$	-			
	\$	-			
End of project life -	\$	-			

Financial Feasibility

Pre-tax IRR and ROI	%	7.9%	Calculate energy production cost?	yes/no	No
After-tax IRR and ROI	%	9.5%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	13.8			
Year-to-positive cash flow	yr	15.6	Project equity	\$	489,375
Net Present Value - NPV	\$	19,763	Project debt	\$	734,062
Annual Life Cycle Savings	\$	2,012	Debt payments	\$/yr	111,877
Benefit-Cost (B-C) ratio	-	1.04	Debt service coverage	-	0.82

Yearly Cash Flows

Year #	Pre-tax \$	After-tax \$	Cumulative \$
0	(489,375)	(146,812)	(146,812)
1	(20,322)	(28,487)	(175,299)
2	(17,331)	(27,511)	(202,810)
3	(14,245)	(26,566)	(229,377)
4	(11,059)	(25,659)	(255,036)
5	(7,771)	(24,796)	(279,832)
6	(4,379)	(23,985)	(303,817)
7	(877)	(23,235)	(327,053)
8	2,736	(22,555)	(349,608)
9	6,465	(21,955)	(371,563)
10	10,313	(21,446)	(393,009)
11	126,160	90,835	(302,174)
12	130,258	93,785	(208,388)
13	134,486	96,830	(111,559)
14	138,849	99,971	(11,588)
15	(73,894)	(53,203)	(64,791)
16	147,997	106,558	41,767
17	152,790	110,009	151,776
18	157,737	113,570	265,346
19	162,840	117,245	382,591
20	168,107	121,037	503,628
21	173,540	124,949	628,577
22	179,147	128,986	757,563
23	184,931	133,151	890,713
24	190,900	137,448	1,028,161
25	197,058	141,882	1,170,043

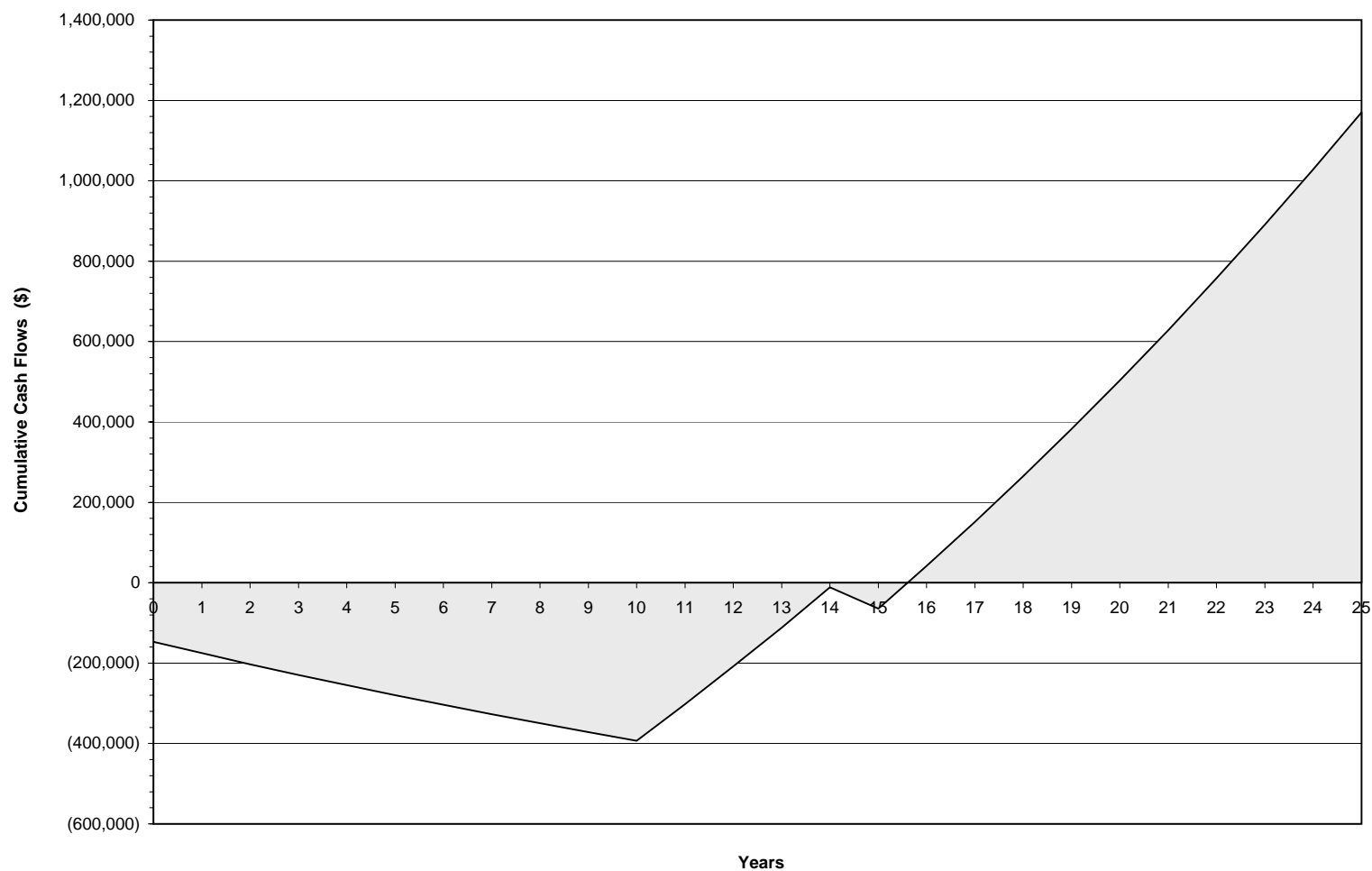
Cumulative Cash Flows Graph

Wind Energy Project Cumulative Cash Flows Green Power Production, Alberta, Canada

Renewable energy delivered (MWh/yr): 1,704

Total Initial Costs: \$ 1,223,437

Net average GHG reduction (t_{CO2}/yr): 770



IRR and ROI: 9.5%

Year-to-positive cash flow: 15.6 yr

Net Present Value: \$ 19,763

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Use sensitivity analysis sheet?

Yes

Perform risk analysis too?

Yes

Project name

Green Power Production

Project location

Alberta, Canada

Perform analysis on

After-tax IRR and ROI

Sensitivity range

20%

Threshold

15.0

%

Sensitivity Analysis for After-tax IRR and ROI

		Avoided cost of energy (\$/kWh)				
RE delivered (MWh)		0.0640 -20%	0.0720 -10%	0.0800 0%	0.0880 10%	0.0960 20%
1,363	-20%	-1.4%	1.2%	3.6%	6.0%	8.3%
1,534	-10%	1.2%	3.9%	6.5%	9.2%	11.9%
1,704	0%	3.6%	6.5%	9.5%	12.5%	15.7%
1,874	10%	6.0%	9.2%	12.5%	16.0%	20.0%
2,045	20%	8.3%	11.9%	15.7%	20.0%	24.8%

		Avoided cost of energy (\$/kWh)				
Initial costs (\$)		0.0640 -20%	0.0720 -10%	0.0800 0%	0.0880 10%	0.0960 20%
978,750	-20%	6.8%	10.5%	14.4%	18.7%	23.6%
1,101,094	-10%	5.0%	8.3%	11.6%	15.1%	19.0%
1,223,437	0%	3.6%	6.5%	9.5%	12.5%	15.7%
1,345,781	10%	2.4%	5.1%	7.8%	10.4%	13.2%
1,468,125	20%	1.4%	4.0%	6.4%	8.8%	11.3%

		Avoided cost of energy (\$/kWh)				
Annual costs (\$)		0.0640 -20%	0.0720 -10%	0.0800 0%	0.0880 10%	0.0960 20%
38,129	-20%	5.6%	8.5%	11.5%	14.6%	18.0%
42,895	-10%	4.6%	7.5%	10.5%	13.5%	16.9%
47,662	0%	3.6%	6.5%	9.5%	12.5%	15.7%
52,428	10%	2.6%	5.6%	8.5%	11.5%	14.6%
57,194	20%	1.6%	4.6%	7.5%	10.4%	13.5%

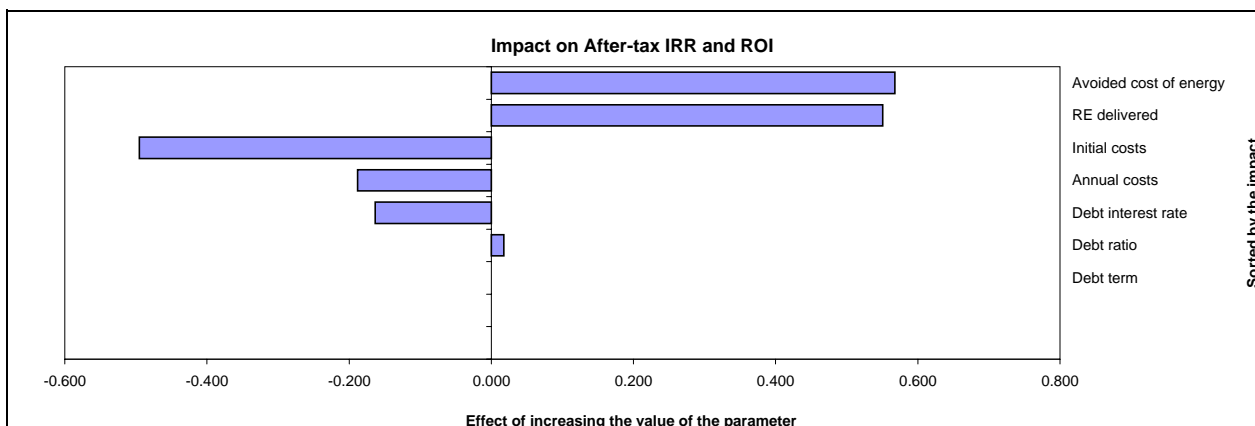
		Debt ratio (%)				
Debt interest rate (%)		48.0% -20%	54.0% -10%	60.0% 0%	66.0% 10%	72.0% 20%
6.8%	-20%	9.6%	10.0%	10.4%	10.9%	11.6%
7.7%	-10%	9.3%	9.6%	9.9%	10.3%	10.8%
8.5%	0%	9.0%	9.2%	9.5%	9.7%	10.1%
9.4%	10%	8.7%	8.9%	9.0%	9.2%	9.4%
10.2%	20%	8.4%	8.5%	8.6%	8.7%	8.8%

		Debt term (yr)				
Debt interest rate (%)		8.0 -20%	9.0 -10%	10.0 0%	11.0 10%	12.0 20%
6.8%	-20%	9.8%	10.1%	10.4%	10.7%	11.1%
7.7%	-10%	9.4%	9.7%	9.9%	10.2%	10.5%
8.5%	0%	9.1%	9.3%	9.5%	9.7%	9.9%
9.4%	10%	8.8%	8.9%	9.0%	9.1%	9.3%
10.2%	20%	8.5%	8.5%	8.6%	8.7%	8.7%

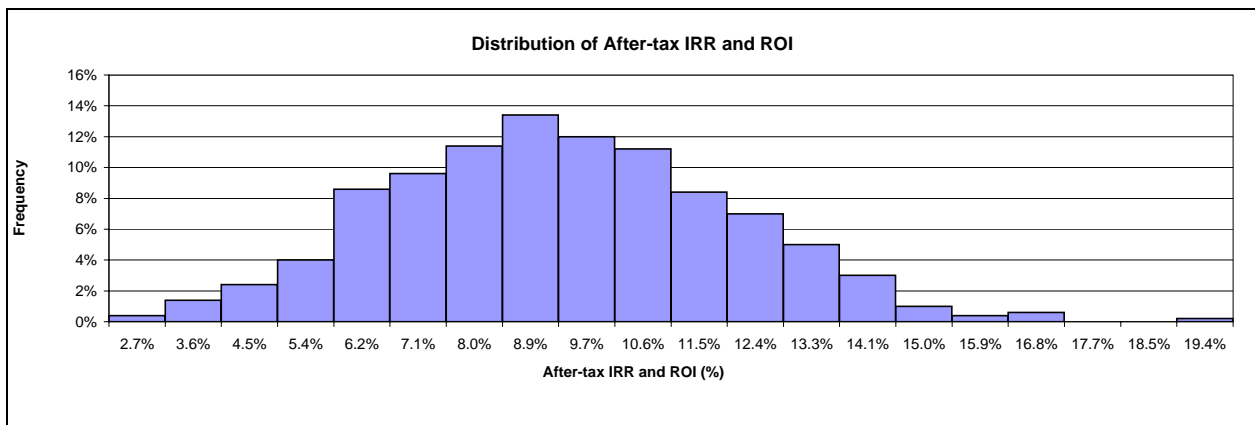
Risk Analysis for After-tax IRR and ROI

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Avoided cost of energy	\$/kWh	0.0800	15%	0.0680	0.0920
RE delivered	MWh	1,704	15%	1,448	1,960
Initial costs	\$	1,223,437	20%	978,750	1,468,125
Annual costs	\$	47,662	15%	40,512	54,811
Debt ratio	%	60.0%	5%	57.0%	63.0%
Debt interest rate	%	8.5%	30%	6.0%	11.1%
Debt term	yr	10	0%	10	10

[Click here to Calculate Risk Analysis](#)



Median	%	9.3%
Level of risk	%	10%
Minimum within level of confidence	%	5.1%
Maximum within level of confidence	%	13.8%



Minimum	Median	Maximum
5.0%	Level of confidence = 90%	5.0%
5.1%	9.3%	13.8%

- With the green power premium included, the financial viability of the project is considerably improved, though still below the typical commercial investment hurdle value of 12-15% IRR on equity. For the first 10 years of the project, operating income does not cover debt service.
- The financial viability of the project would be enhanced by:
 - taking advantage of renewable energy production credits, should they become available; and
 - sales of greenhouse gas emission reduction credits, if available.
- For a single turbine with a distribution line nearby, no substation is required — the turbine transformer is specified to match the distribution line voltage. This accounts for the low transmission line and substation costs.
- It can be expected that at some point during the project lifetime a major component such as the blades or the drivetrain will need to be replaced due to failure. A set of blades or a drivetrain costs roughly 20% to 25% of the purchase price of the turbine. This has been accounted for as a periodic cost.
- Compared with typical figures, the insurance premium is high and the annual parts and labour costs are low; these numbers reflect actual experience at this site.
- The capital costs and exploration expenses of the project have been fully expensed in the first year by setting the depreciation tax basis to 0%. This assumes that, as the first turbine in a future windfarm, the project would satisfy Canadian Renewable and Conservation Expense (CRCE) investment flow-through requirements.
- The green power premium has been included in the avoided cost of energy. If it is included as a RE production credit then those annual costs which are calculated on the basis of the annual energy revenues (excluding the RE production credit) will need to be adjusted accordingly.