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RETScreen® International

Clean Energy Project Analysis Software

Wind Energy Project Model

Click Here to Start

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Features

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Clean Energy Decision Support Centre

www.retscreen.net

- Training & Support
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- e-Textbook

Partners




Version 3.0

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NRCan/CETC - Varennes

Units: Metric

Site Conditions		Estimate	Notes/Range
Project name		Grid-Connected Windfarm	See Online Manual
Project location		Andhra Pradesh, India	
Wind data source		Wind speed	
Nearest location for weather data		Hyderabad	See Weather Database
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	30.0	3.0 to 100.0 m
Wind shear exponent	-	0.15	0.10 to 0.40
Wind speed at 10 m	m/s	5.3	
Average atmospheric pressure	kPa	94.4	60.0 to 103.0 kPa
Annual average temperature	°C	27	-20 to 30 °C

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	250	 Complete Equipment Data sheet
Number of turbines	-	80	
Wind plant capacity	kW	20,000	
Hub height	m	36.0	6.0 to 100.0 m
Wind speed at hub height	m/s	6.4	
Array losses	%	1%	0% to 20%
Airfoil soiling and/or icing losses	%	1%	1% to 10%
Other downtime losses	%	6%	2% to 7%
Miscellaneous losses	%	2%	2% to 6%

Annual Energy Production		Estimate Per Turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	250	20,000	
	MW	0,250	20,000	
Unadjusted energy production	MWh	538	43,022	
Pressure adjustment coefficient	-	0.93	0.93	0.59 to 1.02
Temperature adjustment coefficient	-	0.96	0.96	0.98 to 1.15
Gross energy production	MWh	480	38,410	
Losses coefficient	-	0.90	0.90	0.75 to 1.00
Specific yield	kWh/m²	613	613	150 to 1,500 kWh/m²
Wind plant capacity factor	%	20%	20%	20% to 40%
Renewable energy delivered	MWh	433	34,679	
	GJ	1,561	124,845	

[Complete Cost Analysis sheet](#)

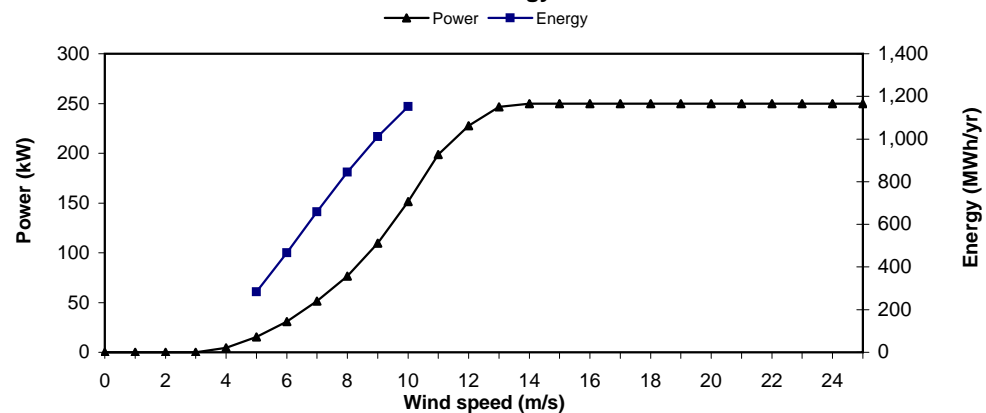
RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	250	See Product Database 6.0 to 100.0 m 7 to 80 m 35 to 5,027 m²
Hub height	m	36.0	
Rotor diameter	m	30	
Swept area	m²	707	
Wind turbine manufacturer		Lagerwey Windturbine	Site specific
Wind turbine model		LAGERWEY 30/250	
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	0.1	-
4	4.4	-
5	15.3	284.0
6	30.8	466.0
7	51.3	659.0
8	76.6	845.0
9	109.8	1,011.0
10	151.5	1,153.0
11	198.6	-
12	227.5	-
13	246.7	-
14	250.0	-
15	250.0	-
16	250.0	-
17	250.0	-
18	250.0	-
19	250.0	-
20	250.0	-
21	250.0	-
22	250.0	-
23	250.0	-
24	250.0	-
25	250.0	-

Power and Energy Curves



[Return to
Energy Model sheet](#)

RETScreen® Cost Analysis - Wind Energy Project
[Search Marketplace](#)

 Type of project: **Standard**

Currency:

India

Second currency:

Netherlands

Cost references:

Second currency

Rate: INR/EUR

53.00000

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	% Foreign	Foreign Amount
Feasibility Study							
Feasibility study	Cost	1	INR 2,190,000	INR 2,190,000			EUR -
Sub-total:				INR 2,190,000	0.3%	0%	EUR -
Development							
Development	Cost	1	INR 6,125,000	INR 6,125,000			EUR -
Sub-total:				INR 6,125,000	0.8%	0%	EUR -
Engineering							
Engineering	Cost	1	INR 5,200,000	INR 5,200,000			EUR -
Sub-total:				INR 5,200,000	0.6%	0%	EUR -
Energy Equipment							
Wind turbine(s)	kW	20,000	INR 30,800	INR 616,000,000		80%	EUR 9,298,113
Spare parts	%	2.0%	INR 616,000,000	INR 12,320,000		100%	EUR 232,453
Transportation	turbine	80	INR 2,500	INR 200,000		50%	EUR 1,887
Sub-total:				INR -			EUR -
Sub-total:				INR 628,520,000	77.5%	80%	EUR 9,532,453
Balance of Plant							
Balance of plant	Cost	1	INR 95,700,000	INR 95,700,000		3%	EUR 46,947
Sub-total:				INR 95,700,000	11.8%	3%	EUR 46,947
Miscellaneous							
Contingencies	%	5%	INR 737,735,000	INR 36,886,750		50%	EUR 347,988
Interest during construction	9.5%	12 month(s)	INR 774,621,750	INR 36,794,533			EUR -
Sub-total:				INR 73,681,283	9.1%	25%	EUR 347,988
Initial Costs - Total				INR 811,416,283	100.0%	65%	EUR 9,927,388

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	% Foreign	Foreign Amount
O&M							
O&M	Cost	1	INR 13,430,000	INR 13,430,000			EUR -
Contingencies	%	10%	INR 13,430,000	INR 1,343,000			EUR -
Annual Costs - Total				INR 14,773,000	100.0%	0%	EUR -

Periodic Costs (Credits)	Period	Unit Cost	Amount	% Foreign	Foreign Amount
		INR -	INR -		EUR -
		INR -	INR -		EUR -
		INR -	INR -		EUR -
End of project life	-	INR -	INR -		EUR -

[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	Grid-Connected Windfarm	Project capacity	20.00 MW	21 tonnes CO ₂ = 1 tonne CH ₄	(IPCC 1996)
Project location	Andhra Pradesh, India	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)
Coal	50.0%	94.6	0.0020	0.0030	35.0%	12.0%	1.117
Large hydro	50.0%	0.0	0.0000	0.0000	100.0%	12.0%	0.000
Electricity mix	100%	153.6	0.0032	0.0049		12.0%	0.559

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%	12.0%	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)
	0.559	0.000	30,518	17,045	0.0%	17,045

[Complete Financial Summary sheet](#)

RETScreen® Financial Summary - Wind Energy Project

Annual Energy Balance					
Project name	Grid-Connected Windfarm				
Project location	Andhra Pradesh, India				
Renewable energy delivered	MWh	34,679	Net GHG reduction	t _{CO2} /yr	17,045
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type	Central-grid		Net GHG emission reduction - 25 yrs	t _{CO2}	426,133

Financial Parameters					
Avoided cost of energy	INR/kWh	4.1600	Debt ratio	%	75.0%
RE production credit	INR/kWh	-	Debt interest rate	%	14.0%
			Debt term	yr	7
GHG emission reduction credit	INR/t _{CO2}	-	Income tax analysis?	yes/no	Yes
			Effective income tax rate	%	35.0%
			Loss carryforward?	yes/no	Yes
			Depreciation method	-	Declining balance
			Depreciation tax basis	%	90.0%
			Depreciation rate	%	30.0%
Energy cost escalation rate	%	5.0%			
Inflation	%	2.5%			
Discount rate	%	12.0%	Tax holiday available?	yes/no	No
Project life	yr	25			

Project Costs and Savings					
Initial Costs			Annual Costs and Debt		
Feasibility study	0.3%	INR	2,190,000	O&M	INR 14,773,000
Development	0.8%	INR	6,125,000		
Engineering	0.6%	INR	5,200,000	Debt payments - 7 yrs	INR 141,912,069
Energy equipment	77.5%	INR	628,520,000	Annual Costs and Debt - Total	INR 156,685,069
Balance of plant	11.8%	INR	95,700,000		
Miscellaneous	9.1%	INR	73,681,283	Annual Savings or Income	
Initial Costs - Total	100.0%	INR	811,416,283	Energy savings/income	INR 144,265,880
Incentives/Grants		INR	-	Capacity savings/income	INR -
				Annual Savings - Total	INR 144,265,880
Periodic Costs (Credits)					
		INR	-		
		INR	-		
		INR	-		
End of project life -		INR	-		

Financial Feasibility					
Pre-tax IRR and ROI	%	26.5%	Calculate energy production cost?	yes/no	No
After-tax IRR and ROI	%	22.8%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	6.3			
Year-to-positive cash flow	yr	7.6	Project equity	INR	202,854,071
Net Present Value - NPV	INR	442,323,639	Project debt	INR	608,562,212
Annual Life Cycle Savings	INR	56,396,251	Debt payments	INR/yr	141,912,069
Benefit-Cost (B-C) ratio	-	3.18	Debt service coverage	-	0.96

Yearly Cash Flows			
Year #	Pre-tax INR	After-tax INR	Cumulative INR
0	(202,854,071)	(202,854,071)	(202,854,071)
1	(5,575,220)	(5,575,220)	(208,429,291)
2	1,620,180	1,620,180	(206,809,111)
3	9,184,815	9,184,815	(197,624,296)
4	17,137,381	17,137,381	(180,486,915)
5	25,497,520	25,497,520	(154,989,395)
6	34,285,856	34,285,856	(120,703,539)
7	43,524,056	43,524,056	(77,179,482)
8	195,146,943	139,123,724	61,944,241
9	205,354,277	137,900,662	199,844,904
10	216,083,227	143,548,365	343,393,269
11	227,360,156	149,950,089	493,343,358
12	239,212,750	157,004,479	650,347,836
13	251,670,088	164,646,891	814,994,728
14	264,762,711	172,838,696	987,833,424
15	278,522,694	181,559,804	1,169,393,228
16	292,983,721	190,803,456	1,360,196,684
17	308,181,172	200,572,588	1,560,769,273
18	324,152,202	210,877,310	1,771,646,582
19	340,935,833	221,733,157	1,993,379,739
20	358,573,047	233,159,886	2,226,539,625
21	377,106,881	245,180,656	2,471,720,281
22	396,582,537	257,821,477	2,729,541,759
23	417,047,483	271,110,844	3,000,652,602
24	438,551,572	285,079,508	3,285,732,110
25	461,147,158	299,794,620	3,585,526,730

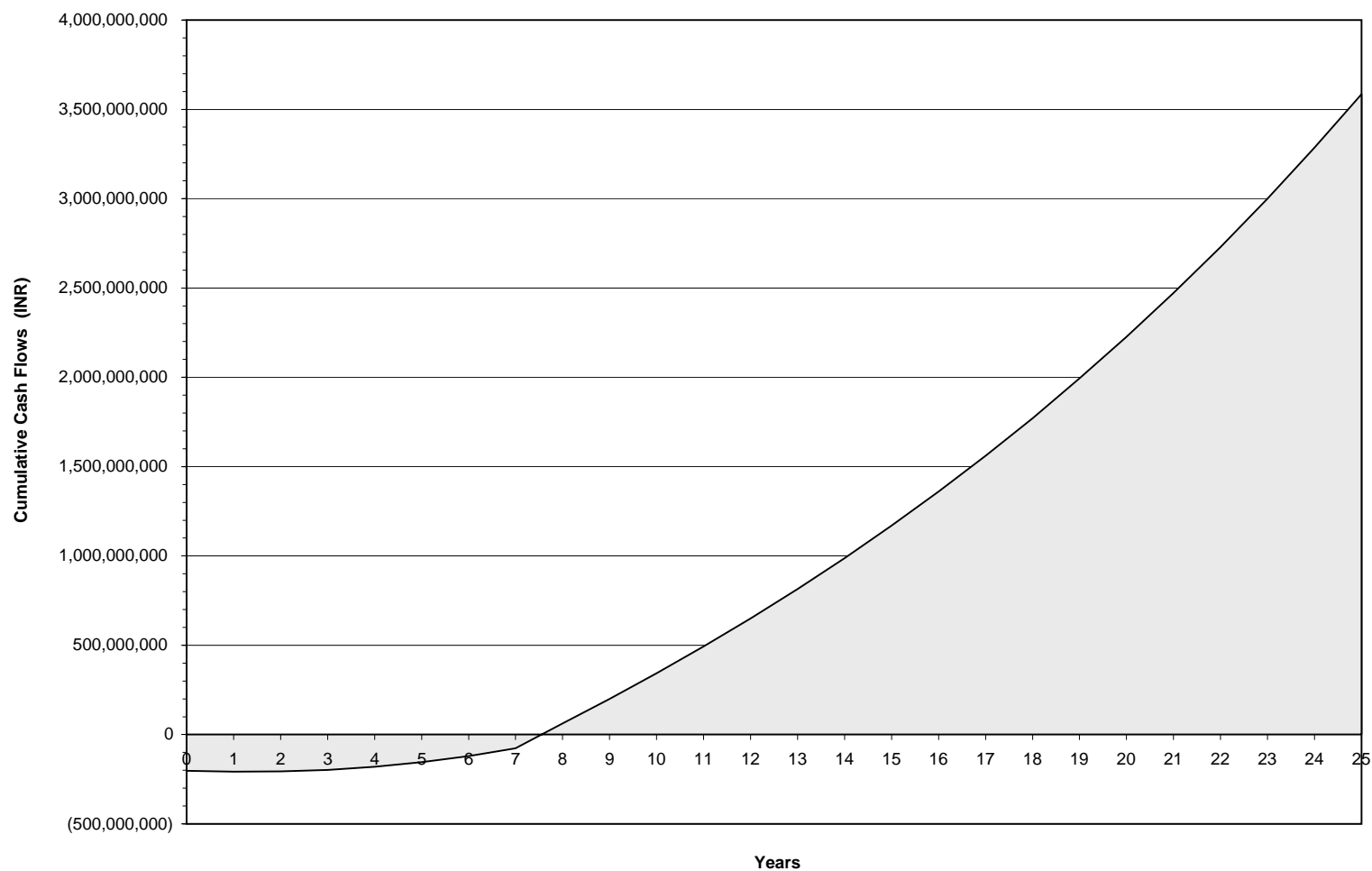
Cumulative Cash Flows Graph

Wind Energy Project Cumulative Cash Flows Grid-Connected Windfarm, Andhra Pradesh, India

Renewable energy delivered (MWh/yr): 34,679

Total Initial Costs: INR 811,416,283

Net average GHG reduction (tCO₂/yr): 17,045



IRR and ROI: 22.8%

Year-to-positive cash flow: 7.6 yr

Net Present Value: INR 442,323,639

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Use sensitivity analysis sheet?

Yes

Perform risk analysis too?

Yes

Project name

Grid-Connected Windfarm

Project location

Andhra Pradesh, India

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 (INR/kWh)				
RE delivered (MWh)		3.3280 -20%	3.7440 -10%	4.1600 0%	4.5760 10%	4.9920 20%
27,743	-20%	11.8%	14.1%	16.4%	18.9%	21.4%
31,211	-10%	14.1%	16.7%	19.5%	22.5%	25.7%
34,679	0%	16.4%	19.5%	22.8%	26.4%	30.3%
38,147	10%	18.9%	22.5%	26.4%	30.8%	35.6%
41,615	20%	21.4%	25.7%	30.3%	35.6%	41.2%

		Avoided cost of energy (INR/kWh)				
Initial costs (INR)		3.3280 -20%	3.7440 -10%	4.1600 0%	4.5760 10%	4.9920 20%
649,133,027	-20%	22.0%	26.5%	31.5%	37.0%	43.1%
730,274,655	-10%	18.8%	22.5%	26.4%	30.8%	35.7%
811,416,283	0%	16.4%	19.5%	22.8%	26.4%	30.3%
892,557,911	10%	14.5%	17.2%	20.0%	23.1%	26.4%
973,699,540	20%	12.9%	15.3%	17.9%	20.5%	23.3%

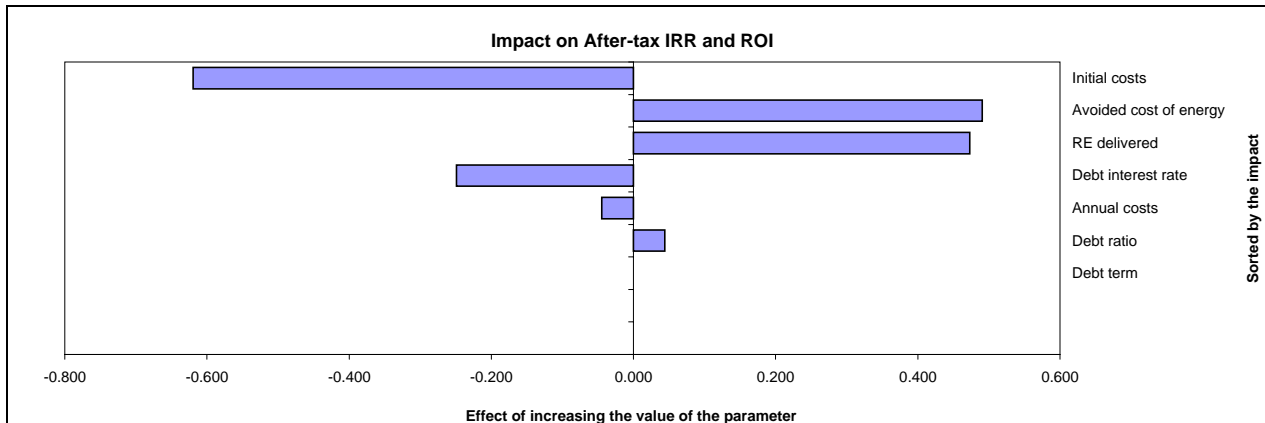
		Avoided cost of energy (INR/kWh)				
Annual costs (INR)		3.3280 -20%	3.7440 -10%	4.1600 0%	4.5760 10%	4.9920 20%
11,818,400	-20%	16.9%	20.1%	23.4%	27.1%	31.1%
13,295,700	-10%	16.7%	19.8%	23.1%	26.8%	30.7%
14,773,000	0%	16.4%	19.5%	22.8%	26.4%	30.3%
16,250,300	10%	16.2%	19.2%	22.5%	26.1%	30.0%
17,727,600	20%	15.9%	18.9%	22.2%	25.7%	29.6%

		Debt ratio (%)				
Debt interest rate (%)		60.0% -20%	67.5% -10%	75.0% 0%	82.5% 10%	90.0% 20%
11.2%	-20%	22.5%	23.5%	24.7%	26.3%	28.6%
12.6%	-10%	21.9%	22.7%	23.7%	25.0%	26.7%
14.0%	0%	21.4%	22.0%	22.8%	23.8%	25.0%
15.4%	10%	20.8%	21.3%	21.9%	22.6%	23.5%
16.8%	20%	20.3%	20.6%	21.1%	21.6%	22.2%

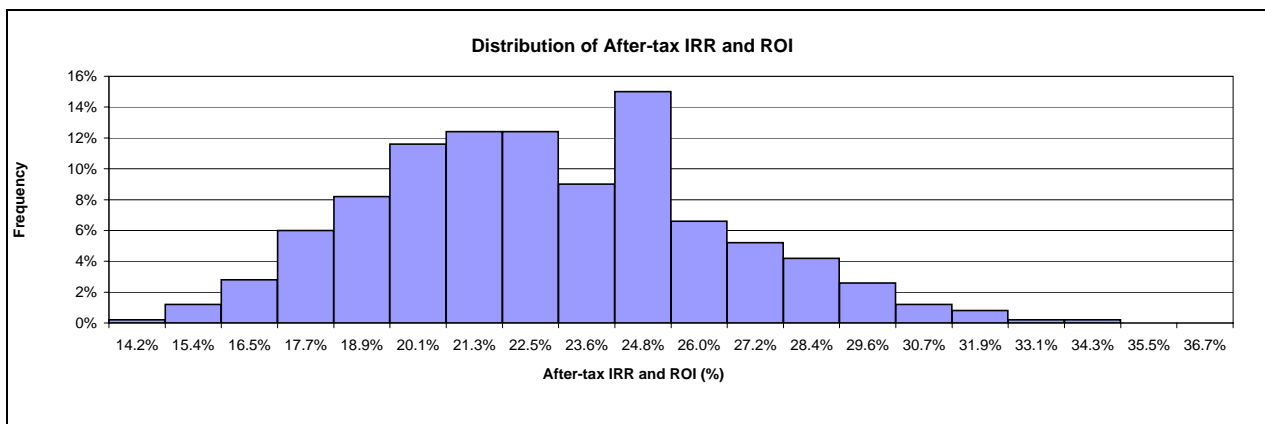
		Debt term (yr)				
Debt interest rate (%)		5.6 -20%	6.3 -10%	7.0 0%	7.7 10%	8.4 20%
11.2%	-20%	24.6%	24.5%	24.7%	26.5%	26.8%
12.6%	-10%	23.8%	23.6%	23.7%	25.4%	25.6%
14.0%	0%	23.1%	22.8%	22.8%	24.4%	24.5%
15.4%	10%	22.4%	22.1%	21.9%	23.4%	23.3%
16.8%	20%	21.8%	21.3%	21.1%	22.4%	22.3%

Risk Analysis for After-tax IRR and ROI

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Avoided cost of energy	INR/kWh	4.1600	15%	3.5360	4.7840
RE delivered	MWh	34,679	15%	29,477	39,881
Initial costs	INR	811,416,283	20%	649,133,027	973,699,540
Annual costs	INR	14,773,000	15%	12,557,050	16,988,950
Debt ratio	%	75.0%	5%	71.3%	78.8%
Debt interest rate	%	14.0%	30%	9.8%	18.2%
Debt term	yr	7	0%	7	7



Median	%	22.6%
Level of risk	%	10%
Minimum within level of confidence	%	17.4%
Maximum within level of confidence	%	29.0%



Minimum	Median	Maximum
5.0%	Level of confidence = 90%	5.0%
17.4%	22.6%	29.0%

- The real project had a complex financing structure with several small investors who contributed equity and/or debt. This has been simplified in the case presented. Also, there was a grant component that improved the project viability but was excluded from the case presented.
- A maximum turbine capacity is prescribed to ensure that the case study is consistent with the real project. Large turbines would be difficult to transport and commission on the remote and complex terrain.
- The wind speeds were measured at a 20-m height and extrapolated to 30 m. The measured data at 20 m is not available.
- Array losses are expected to be small due to the advantageous ridge-top location of the wind turbines.