



Natural Resources
Canada

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Canada

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
- Internet Forums
- Marketplace
- Case Studies
- e-Textbook

Partners



Units: **Metric**

Site Conditions		Estimate	Notes/Range
Project name		Offshore Windfarm	See Online Manual
Project location		Copenhagen, Denmark	
Wind data source		Wind speed	
Nearest location for weather data		Copenhagen	See Weather Database
Annual average wind speed	m/s	7.2	
Height of wind measurement	m	50.0	3.0 to 100.0 m
Wind shear exponent	-	0.10	0.10 to 0.40
Wind speed at 10 m	m/s	6.1	
Average atmospheric pressure	kPa	101.3	60.0 to 103.0 kPa
Annual average temperature	°C	8	-20 to 30 °C

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	2,000	 Complete Equipment Data sheet
Number of turbines	-	20	
Wind plant capacity	kW	40,000	
Hub height	m	64.0	6.0 to 100.0 m
Wind speed at hub height	m/s	7.4	
Wind power density at hub height	W/m²	471	
Array losses	%	4%	0% to 20%
Airfoil soiling and/or icing losses	%	1%	1% to 10%
Other downtime losses	%	4%	2% to 7%
Miscellaneous losses	%	3%	2% to 6%

Annual Energy Production		Estimate Per Turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	2,000	40,000	
	MW	2,000	40,000	
Unadjusted energy production	MWh	5,530	110,599	
Pressure adjustment coefficient	-	1.00	1.00	0.59 to 1.02
Temperature adjustment coefficient	-	1.02	1.02	0.98 to 1.15
Gross energy production	MWh	5,641	112,811	
Losses coefficient	-	0.89	0.89	0.75 to 1.00
Specific yield	kWh/m²	1,101	1,101	150 to 1,500 kWh/m²
Wind plant capacity factor	%	28%	28%	20% to 40%
Renewable energy delivered	MWh	4,992	99,839	
	GJ	17,971	359,422	

[Complete Cost Analysis sheet](#)

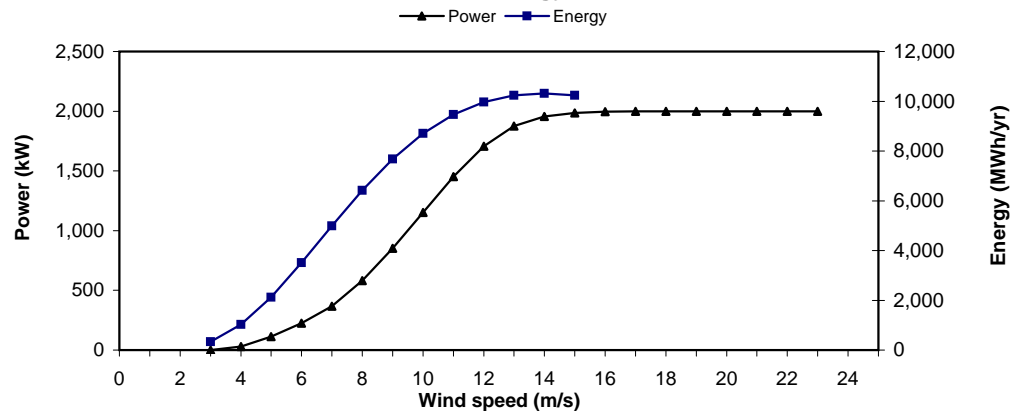
RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	2,000	See Product Database 6.0 to 100.0 m 7 to 80 m 35 to 5,027 m²
Hub height	m	64.0	
Rotor diameter	m	76	
Swept area	m²	4,536	
Wind turbine manufacturer		Bonus Energy	Rayleigh wind distribution
Wind turbine model		AN BONUS 2 MW	
Energy curve data source	-	Standard	
Shape factor	-	2.0	

Wind Turbine Production Data

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	-	-
1	-	-
2	-	-
3	0.1	334.5
4	29.1	1,025.6
5	113.7	2,123.6
6	225.2	3,504.9
7	366.3	4,987.5
8	582.0	6,415.3
9	852.5	7,677.8
10	1,151.4	8,705.9
11	1,451.2	9,469.7
12	1,707.5	9,973.0
13	1,875.2	10,243.3
14	1,956.2	10,319.2
15	1,986.6	10,242.1
16	1,996.2	-
17	1,999.0	-
18	1,999.7	-
19	1,999.9	-
20	2,000.0	-
21	2,000.0	-
22	2,000.0	-
23	2,000.0	-
24	-	-
25	-	-

Power and Energy Curves



[Return to
Energy Model sheet](#)

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

 Type of project: **Standard**

 Currency: **Euro symbol**

 Cost references: **None**

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Feasibility study	Cost	1	€ 680,000	€ 680,000	-	-	-
Sub-total:				€ 680,000	1.3%		
Development							
Planning & consultants	Cost	1	€ 2,150,000	€ 2,150,000	-	-	-
Sub-total:				€ 2,150,000	4.1%		
Engineering							
			€ -	€ -	-	-	-
Sub-total:				€ -	0.0%		
Energy Equipment							
Wind turbine(s)	kW	40,000	€ 653	€ 26,100,000	-	-	-
Spare parts	%	0.0%	€ 26,100,000	€ -	-	-	-
Transportation	turbine	20	€ -	€ -	-	-	-
Sub-total:				€ 26,100,000	49.8%		
Balance of Plant							
Turb. found., grid conn. & co-op	Cost	1	€ 21,840,000	€ 21,840,000	-	-	-
Sub-total:				€ 21,840,000	41.7%		
Miscellaneous							
Contingencies	%	3%	€ 50,770,000	€ 1,610,000	-	-	-
Interest during construction	0.0%	12 month(s)	€ 52,380,000	€ -	-	-	-
Sub-total:				€ 1,610,000	3.1%		
Initial Costs - Total				€ 52,380,000	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
O&M	Cost	1	€ 898,554	€ 898,554	-	-	-
Contingencies	%	0%	€ 898,554	€ -	-	-	-
Annual Costs - Total				€ 898,554	100.0%		

Periodic Costs (Credits)	Period	Unit Cost	Amount	Interval Range	Unit Cost Range
		€ -	€ -	-	-
		€ -	€ -	-	-
		€ -	€ -	-	-
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	Offshore Windfarm	Project capacity	40.00 MW	21 tonnes CO ₂ =	1 tonne CH ₄	(IPCC 1996)
Project location	Copenhagen, Denmark	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)
#6 oil	17.0%	77.4	0.0030	0.0020	30.0%	8.0%	1.018
Natural gas	28.0%	56.1	0.0030	0.0010	45.0%	8.0%	0.491
Coal	55.0%	94.6	0.0020	0.0030	35.0%	8.0%	1.069
Electricity mix	100%	247.2	0.0073	0.0070		8.0%	0.898

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

	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)
Electricity system	0.898	0.000	91,852	82,513	0.0%	82,513

[Complete Financial Summary sheet](#)

RETScreen® Financial Summary - Wind Energy Project
Annual Energy Balance

Project name	Offshore Windfarm				
Project location	Copenhagen, Denmark				
Renewable energy delivered	MWh	99,839	Net GHG reduction	t _{CO2} /yr	82,513
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type	Central-grid		Net GHG emission reduction - 25 yrs	t _{CO2}	2,062,814

Financial Parameters

Avoided cost of energy	€/kWh	0.0570	Debt ratio	%	0.0%
RE production credit	€/kWh	0.023			
RE production credit duration	yr	6			
RE credit escalation rate	%	0.0%			
GHG emission reduction credit	€/t _{CO2}	-	Income tax analysis?	yes/no	No
Energy cost escalation rate	%	2.5%			
Inflation	%	2.5%			
Discount rate	%	9.0%			
Project life	yr	25			

Project Costs and Savings

Initial Costs			Annual Costs and Debt		
Feasibility study	1.3%	€ 680,000	O&M	€	898,554
Development	4.1%	€ 2,150,000			
Engineering	0.0%	€ -			
Energy equipment	49.8%	€ 26,100,000	Annual Costs and Debt - Total	€	898,554
Balance of plant	41.7%	€ 21,840,000			
Miscellaneous	3.1%	€ 1,610,000	Annual Savings or Income		
Initial Costs - Total	100.0%	€ 52,380,000	Energy savings/income	€	5,690,842
Incentives/Grants		€ 680,000	Capacity savings/income	€	-
			RE production credit income - 6 yrs	€	2,296,305
			Annual Savings - Total	€	7,987,147
Periodic Costs (Credits)					
	€	-			
	€	-			
	€	-			
End of project life -	€	-			

Financial Feasibility

Pre-tax IRR and ROI	%	13.1%	Calculate energy production cost?	yes/no	No
After-tax IRR and ROI	%	13.1%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	7.3			
Year-to-positive cash flow	yr	7.1	Project equity	€	52,380,000
Net Present Value - NPV	€	17,924,191			
Annual Life Cycle Savings	€	1,824,795			
Benefit-Cost (B-C) ratio	-	1.34			

Yearly Cash Flows

Year #	Pre-tax €	After-tax €	Cumulative €
0	(51,700,000)	(51,700,000)	(51,700,000)
1	7,208,400	7,208,400	(44,491,600)
2	7,331,202	7,331,202	(37,160,398)
3	7,457,075	7,457,075	(29,703,324)
4	7,586,094	7,586,094	(22,117,230)
5	7,718,339	7,718,339	(14,398,891)
6	7,853,889	7,853,889	(6,545,002)
7	5,696,524	5,696,524	(848,477)
8	5,838,938	5,838,938	4,990,460
9	5,984,911	5,984,911	10,975,371
10	6,134,534	6,134,534	17,109,905
11	6,287,897	6,287,897	23,397,802
12	6,445,094	6,445,094	29,842,896
13	6,606,222	6,606,222	36,449,118
14	6,771,377	6,771,377	43,220,496
15	6,940,662	6,940,662	50,161,157
16	7,114,178	7,114,178	57,275,336
17	7,292,033	7,292,033	64,567,369
18	7,474,334	7,474,334	72,041,702
19	7,661,192	7,661,192	79,702,894
20	7,852,722	7,852,722	87,555,616
21	8,049,040	8,049,040	95,604,656
22	8,250,266	8,250,266	103,854,922
23	8,456,522	8,456,522	112,311,444
24	8,667,936	8,667,936	120,979,380
25	8,884,634	8,884,634	129,864,014

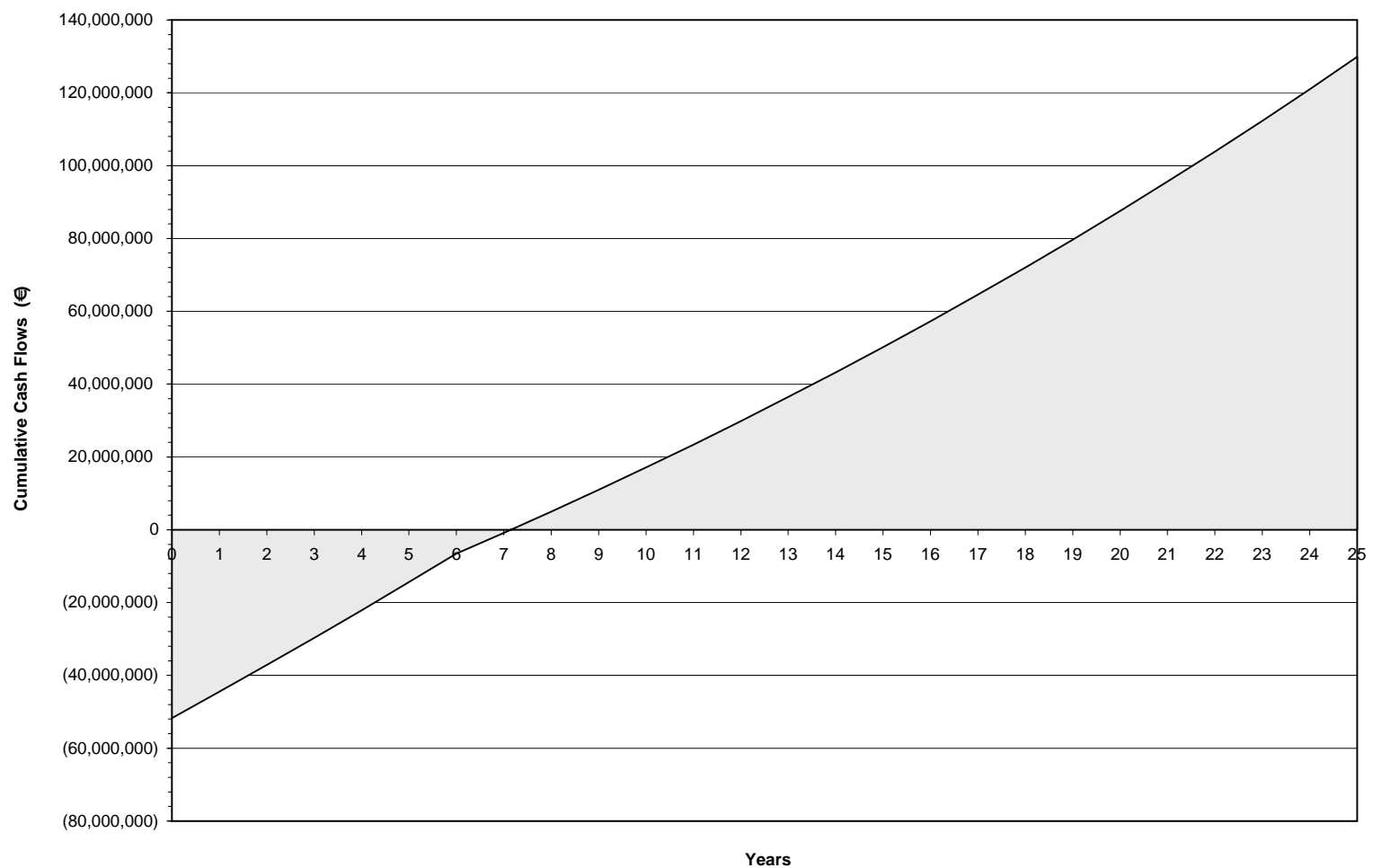
Cumulative Cash Flows Graph

Wind Energy Project Cumulative Cash Flows Offshore Windfarm, Copenhagen, Denmark

Renewable energy delivered (MWh/yr): 99,839

Total Initial Costs: € 52,380,000

Net average GHG reduction (tCO₂/yr): 82,513



IRR and ROI: 13.1%

Year-to-positive cash flow: 7.1 yr

Net Present Value: € 17,924,191

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Use sensitivity analysis sheet?

Yes

Perform risk analysis too?

No

Project name

Offshore Windfarm

Project location

Copenhagen, Denmark

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)		0.0456 -20%	0.0513 -10%	0.0570 0%	0.0627 10%	0.0684 20%
79,871	-20%	-9,496,665	-3,860,966	1,774,734	7,410,434	13,046,134
89,855	-10%	-2,830,862	3,509,300	9,849,462	16,189,625	22,529,787
99,839	0%	3,834,941	10,879,566	17,924,191	24,968,815	32,013,440
109,823	10%	10,500,745	18,249,832	25,998,919	33,748,006	41,497,093
119,807	20%	17,166,548	25,620,097	34,073,647	42,527,197	50,980,746

		Avoided cost of energy (€/kWh)				
Initial costs (€)		0.0456 -20%	0.0513 -10%	0.0570 0%	0.0627 10%	0.0684 20%
41,904,000	-20%	14,310,941	21,355,566	28,400,191	35,444,815	42,489,440
47,142,000	-10%	9,072,941	16,117,566	23,162,191	30,206,815	37,251,440
52,380,000	0%	3,834,941	10,879,566	17,924,191	24,968,815	32,013,440
57,618,000	10%	-1,403,059	5,641,566	12,686,191	19,730,815	26,775,440
62,856,000	20%	-6,641,059	403,566	7,448,191	14,492,815	21,537,440

		Avoided cost of energy (€/kWh)				
Annual costs (€)		0.0456 -20%	0.0513 -10%	0.0570 0%	0.0627 10%	0.0684 20%
718,843	-20%	6,059,560	13,104,184	20,148,809	27,193,434	34,238,058
808,699	-10%	4,947,250	11,991,875	19,036,500	26,081,124	33,125,749
898,554	0%	3,834,941	10,879,566	17,924,191	24,968,815	32,013,440
988,409	10%	2,722,632	9,767,257	16,811,881	23,856,506	30,901,131
1,078,265	20%	1,610,323	8,654,948	15,699,572	22,744,197	29,788,822

		RE production credit (€/kWh)				
RE delivered (MWh)		0.018 -20%	0.021 -10%	0.023 0%	0.025 10%	0.028 20%
79,871	-20%	126,568	950,651	1,774,734	2,598,817	3,422,900
89,855	-10%	7,995,276	8,922,369	9,849,462	10,776,556	11,703,649
99,839	0%	15,863,983	16,894,087	17,924,191	18,954,294	19,984,398
109,823	10%	23,732,691	24,865,805	25,998,919	27,132,033	28,265,147
119,807	20%	31,601,398	32,837,523	34,073,647	35,309,771	36,545,896

- The total power purchase price (including green energy attributes) starts at €0.080/kWh for years 1 through 6 and drops off to a fixed €0.057/kWh for the rest of the project's life. To model this in RETScreen, the "Avoided cost of energy" (i.e. purchase price) is set to €0.057/kWh for the life of the project and a premium of €0.023/kWh is added as a "RE production credit" in the first six years.
- All component costs include transport and installation.
- The cost of the feasibility study is credited as an incentive or grant in the "Project Costs and Savings" section of the Financial Summary worksheet.
- All costs are final, as-built costs reported by H.C. Sørensen. Only the grid connection cost is approximated based on feasibility study projections.