NEIGHBOURHOOD PROGRAMME
LITHUANIA, POLAND AND KALININGRAD REGION
OF RUSSIAN FEDERATION

Perspectives of **O**ffshore **W**ind **E**nergy development in marine areas of Lithuania, Poland and **R**ussia

2.3. The model for economical feasibility study of offshore wind power parks

Innovations company JSC "Eksponente"

Klaipeda, Lithuania
2008

Content

Abbreviations

EZ	– Economical zone
GE	– “General electrics”
INTERREG	– EC initiative for stimulation of interregional cooperation
JSC	– Joint Stock Company
MW	– Mega watt
OWEM	– Offshore Wind power Park Economical Modelling
POWER	– Perspectives of Offshore Wind Energy development in marine areas of Lithuania, Poland and Russia
SSI	– Strategic Self-Management Institute
WP	– Wind power park

Introduction

According to task 2.3 of INTERREG IIIa project POWER (**P**erspectives of **O**ffshore **W**ind **E**nergy development in marine areas of Lithuania, Poland and **R**ussia) the model of economical feasibility study of offshore wind power parks presented in this report.

The problem. Offshore wind power development is connected to big amount of factors and not formed jet normative of works costs and its dependency from marine conditions of planning wind power parks. Having deal with big amount of variables and specific mode of its evaluation it's useful to create and apply special software tool on which ground could be possible to model and calculate different variants of offshore wind park installations.

The main aim is to create and apply special software tool on which ground could be possible to model and calculated different variants of offshore wind parks installations.

Main tasks are:

1. To create models for dislocation of different kind and capacity wind turbines in marked marine areas;
2. To create models for calculation of capital costs depending from geographical location, marine dept and high of rotor axis;
3. To create models for calculation of wind power distribution depending from geographical location and high of rotors axis;
4. To create models for calculation of electricity production depending from geographical and hydro- meteorological parameters;
5. To create models for calculation of revenues and repayment parameters of offshore wind power parks.

Main scientific subject of the studio is interdependence and adhesion of different physical, technical, economical, environmental parameters, what results efficiency of investments and other economical parameters of offshore wind parks.

Main methods of the research are economical analysis, extrapolation, mathematical modelling.

1. The characteristics of potential sites for wind power development in marine areas of Poland, Russia (Kaliningrad region) and Lithuania

During project POWER works were preliminary defined potential plots where could be constructed wind power parks (Figure 1).

All of them are located in different distance from coast, in different dept and wind conditions, different area of plots. There aren't equal technical and hydro meteorological conditions in different parks, but between different turbines in same plot also.

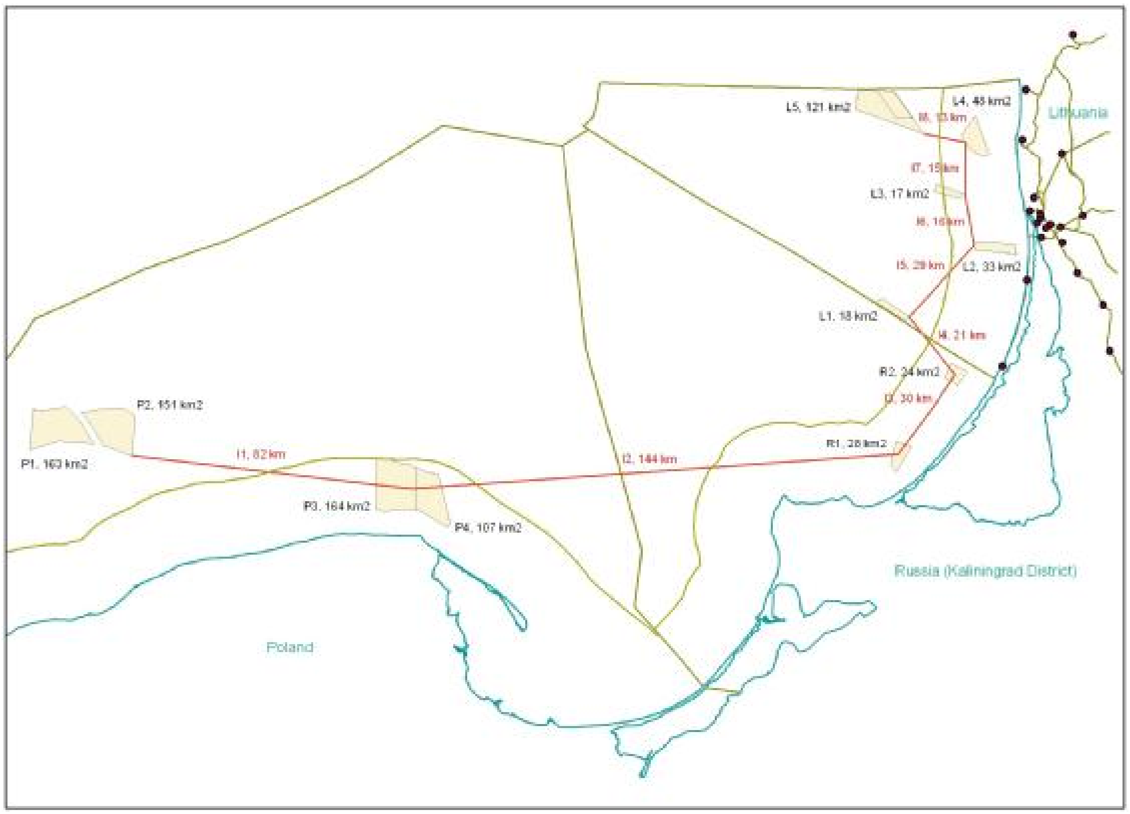


Figure 1. Location and line interconnection of potential wind power parks in marine territories of Poland, Lithuania and Russia (Kaliningrad region)

Provided big number of wind turbines requires having enough universal tools for calculation and evaluation different variants of wind parks construction and wind turbines installation. For this aim in schedule of POWER project were provided to work out model for economical feasibility study of offshore wind power parks.

This kind of software related to calculations of onshore wind power parks is worked out and are on use for scientific and practical needs. Offshore wind power is new kind of energy projects. There are more different features comparing to on-shore wind parks, especially related to lack of reliable wind measurements on see in high of axis of offshore wind turbines, what reaches 100 and more meters.

Table 1. Data of defined plots for wind power park's installation

No.	Plot	National EZ	Area, km^2	Distance from shore, km	dept, m
1	P1	Poland	163	41	42
2	P2	Poland	151	35	30
3	P3	Poland	164	11	26
4	P4	Poland	107	12	28
5	R1	Russia	28	11	24
6	R2	Russia	24	8	28
7	L1	Lithuania	38	52	38
8	L2	Lithuania	33	20	32
9	L3	Lithuania	17	17	37
10	L4	Lithuania	48	12	26
11	L5	Lithuania	121	31	32
		Total:	894		
			Average:	23	31

More strong technological requirements are laid down in connection to construction of turbines foundations in big dept. Marine conditions ask more expenses related to transportation, erection and maintenance of offshore wind power parks. Specific requirements connected to cabling of high voltage cable and construction of substation in open Sea.

2. Software for economical feasibility study of offshore wind power park

Taking into account general and specific requirement were worked out **S**oftware for **Offshore W**ind power Park **E**conomical **M**odelling – **OWEM**.

The modelling toll consists of two parts:

a) Modelling modules and
b) Virtual simulator.

The toll OWEM is realized on 5 range levels by joining technologies MS EXCEL and Web Flash design (Table 2).

Table 2. Operational levels of OWEM.

Range	Level	Modules	Simulator
1	INTERREG	-	Flash screen
2	National	National EZ	Flash screen
3	Plot	Plot in national EZ	Flash screen
4	Types of turbines	Choice number of turbines	Data
5	Capacity	Calculation of Wind power park parameters	Data

The tool is prepared for be used in two applications: 1) ***Modelling*** - for economical modelling by entering new more exact data and 2) for ***Simulation*** of economical parameters on presentation and demonstration needs.

2.1. Software for offshore wind power park economical modelling

Modelling modules consist of 12 interrelated Worksheets with large scale of variables (Table 3).

Table 3. Main modules of OWEM

Worksheet No	Content
1.	Screening sheet for output data to Web page.
2.	Module for calculation of output parameters in selected plots of Poland, Lithuania and Russia
3.	Modules for calculation of number of turbines, total capacity and approximate investments; park interconnection parameters
4.	Weibull distribution module
5.	Module for calculation of Wibull distribution; sample - Vestas V90
6.	Data of different wind turbines Power curves
7.	Power curves of different kind of turbines
8.	Module for wind conditions evaluation
9.	Module for calculation of grid connection costs
10.	Module for calculation of economic inputs
11.	Module for calculation of capital costs
12.	Module for calculation of revenus and other economical parameters of wind power parks

Sample view of Worksheets presented in Appendix of this report. They are using for modelling different variants of location of different kinds of wind turbines in different plots. Hawing no exact wind parameters and installations costs, this tool gives possibility approximately estimate investment efficiency. After accumulation of more precise data this model could give practically acceptable outcomes related to each investment portfolio.

2.2. Web based Simulator for offshore wind power park economy demonstration

The virtual presentation of technical and economical parameters provided to realise on the ground of the web platform of project POWER using Flash technologies. Visitors of the site will be able to review main parameters of each plot like this shown in Figure 2-4.

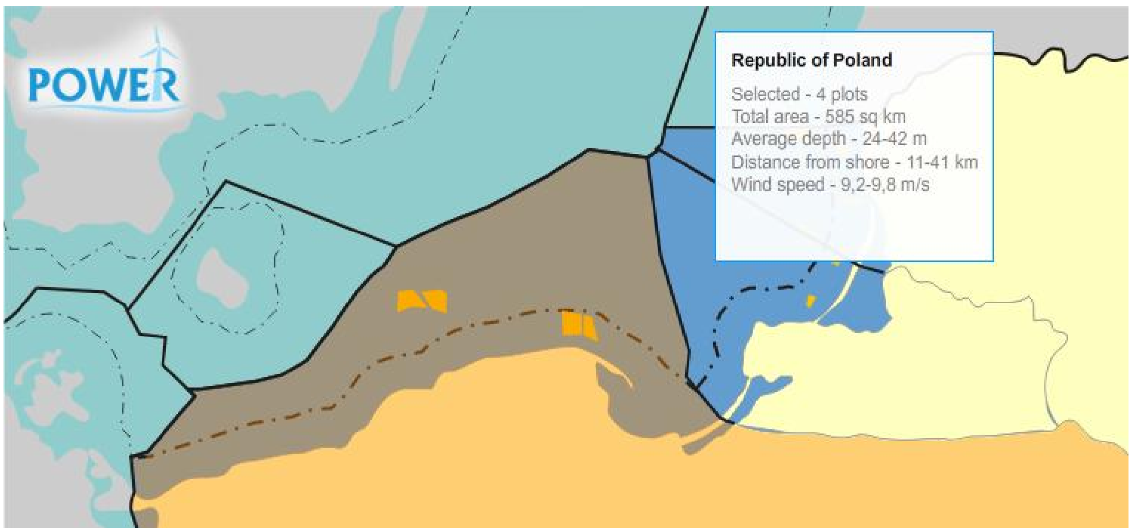


Figure 2. The sample picture for flash presentation of parameters of wind parks in Polish EZ.

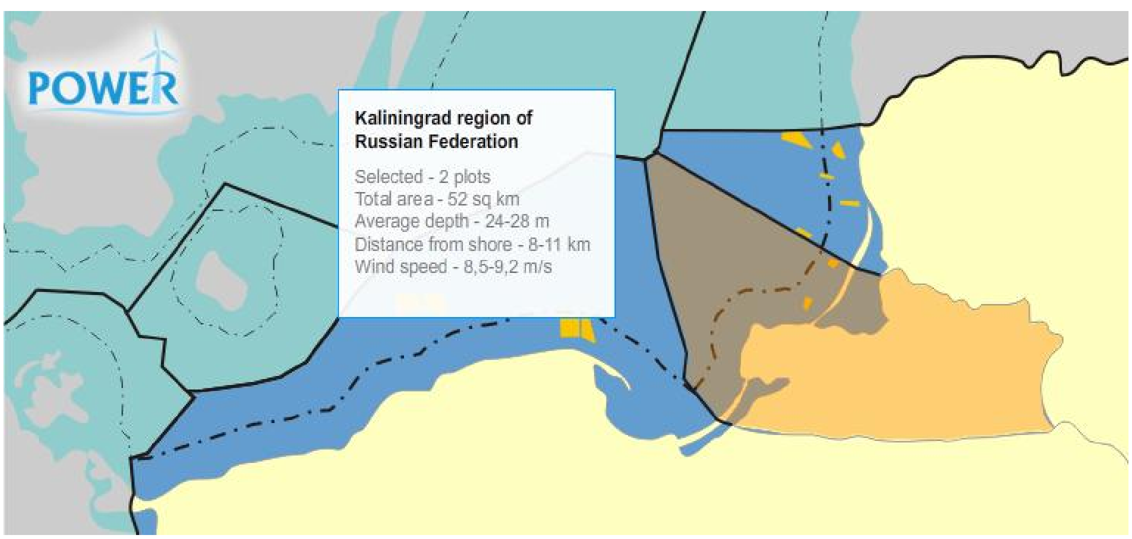


Figure 3. The sample picture for flash presentation of selected plots in Russian EZ.

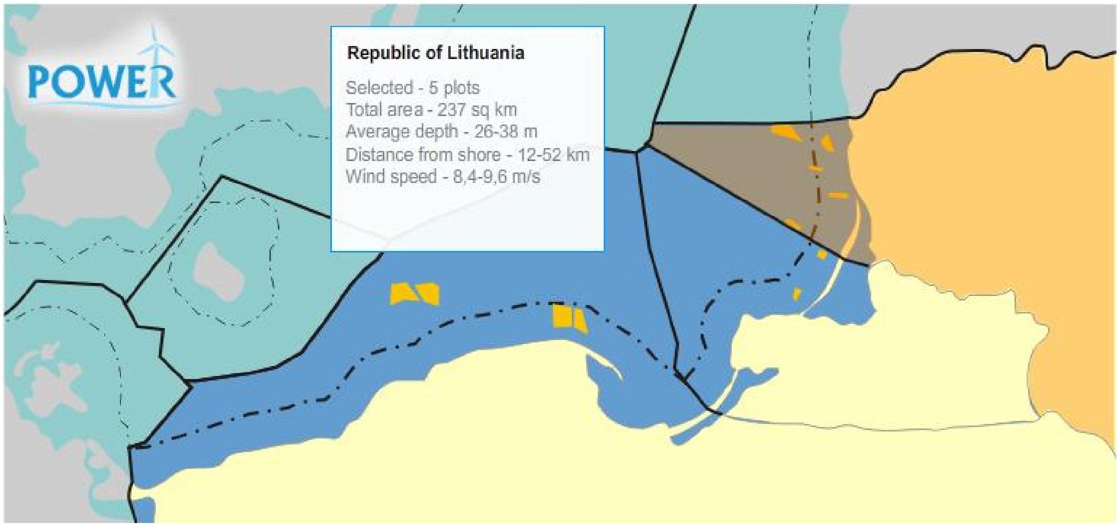


Figure 4. The sample picture for flash presentation of selected plots.

There are possibilities to flash preview of parameters of each defined plot in national marine areas of Poland, Lithuania and Russia like shown in Figures 5, 5a, 5b.

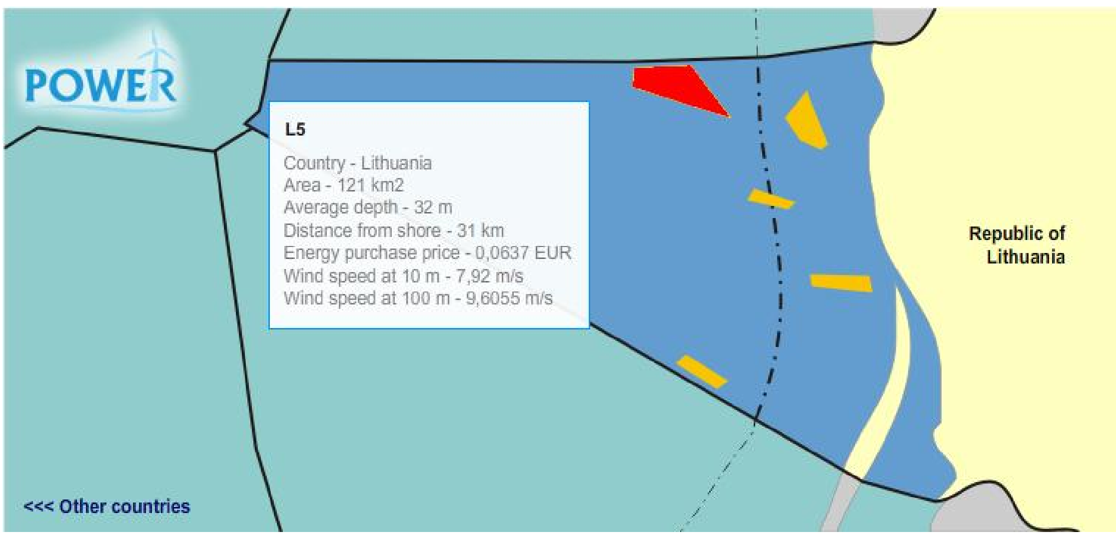


Figure 5. The sample picture for flash presentation of selected plot L5 in Lithuanian EZ.

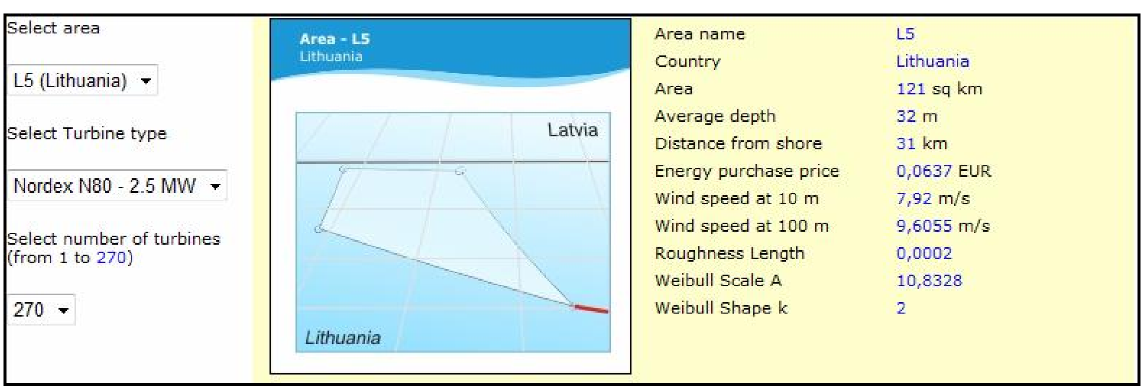
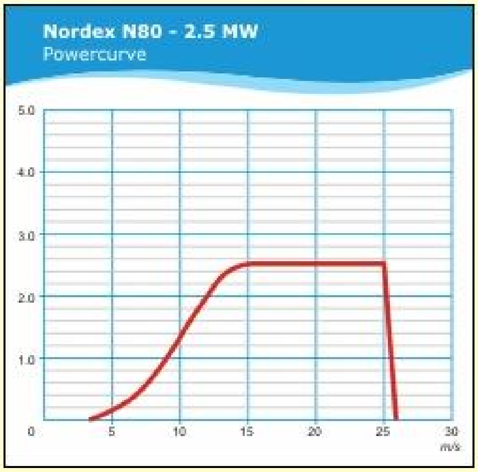


Figure 5a. The sample picture for presentation of technical data of selected plot.



Manufacturer	Nordex
Turbine model	Nordex N80
Rated power	2.500 MW
Rotor diameter	80 m
Hub height	100 m
Swept area	5.026 sq m
Price	3.500.000 EUR
Annual Energy output	10.006 MWh
Capacity factor	45,7 %

Wind Power Park	
Max number of turbines	270
Max capacity	675 MW
Number of turbines	270
Total capacity	675 MW
Net Energy for sale	2.438.144 MWh
Capacity factor	41,2 %

Capital Costs	1.596.710.000 EUR
Capital Cost per MW	2.365.496 EUR
Revenues	178.243.946 EUR
Power Sold	2.438.144 MWh
CO2 credits	1.526.278 t
Annual Expenses	2.668.963 EUR
Investments	
Equity	10 %
Equity	159.671.000 EUR
Debt	1.437.039.000 EUR
Interest rate	6 %
Return period	8 years

Figure 5b. The sample picture for presentation of technical and economical data of selected plot.

The Simulator for demonstration of technical and economical data for chosen plots is located on Web site of project POWER - http://corpi.ku.lt/power/

It was approved and used for demonstration of outcomes of project POWER during Final conference of the project POWER in Palanga, in December 12.

The OWEM was presented by Stasys Paulauskas (SSI) and demonstrated during Energy Forum conference “Wind Power in the Nordic and Baltic Region“ in Gothenburg, Sweden, in February 7, 2008. http://www.energyforum.com/events/conferences/2008/c801/.

Conclusion:

Overall tool OWEM is appropriate for approximate modelling of offshore wind power park’s technical and economical data same for its demonstration on Web platform. Entering exact data the toll could be used for practical design of offshore wind parks.

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Appendixes

Worksheet 1. Screening sheet for output data to Web page.

Start											
Areas		**11**	**Selected Area**			**Selected Turbine**			**Capital Costs**	**EUR**	**1.160.311.010**
1	P1		Area name		L5	Manufacturer		Repower	Development Expenses		1.661.000
2	P2		Country		Lithuania	Turbine Model		Repower M5	Equipment		820.225.000
3	P3		FID		0	Rated Power	kW	5.000	Construction		237.859.100
4	P4		Area	km2	121	Rotor Diameter	m	126	Grid Interconnection		69.750.000
5	R1		Average Depth	m	32	Hub Height	m	100	Additional Expenses		30.815.910
6	R2		Distance from Shore	km	31	Swept Area	m2	12.469	**Total Capital Cost per MW**		**2.129.011**
7	L1	44	Power Purchase Price	EUR/kWh	0,0869	Price	EUR	7.000.000			
8	L2	37				Energy Output	MWh	22.995	**Revenues**	**EUR**	**217.787.523**
9	L3	41				Capacity factor	%	52,5			
10	L4	35							Power Sold	MWh	2.262.116
11	L5	45	**Wind Speed**			**Wind Park**	**L5**		CO2 credits	t	1.416.085
		40,3									
Turbine		**4**	10 m height	m/s	7,92	Max number of turbines		109	**Annual Expenses**	**EUR**	**1.467.472**
			100 m height	m/s	9,6055	Max Capacity	MW	545			
1	Nordex N80		Roughness Length		0,0002				**Investments**		
2	Vestas V90		Weibull	Scale A	10,8328	Number of turbines		109			
3	GE 3.6 sl		Weibull	Shape k	2	Total Capacity	MW	545	Equity	%	**10**
4	Repower M5					Net Energy for Sale	MWh	2.262.116	Equity	EUR	116.031.101
5	E-112					Capacity factor	%	47,4	Debt	EUR	1.044.279.909
									Interest rate	%	**6**
Turbines		**109**							Return	years	5
max	109										

Worksheet 2. Module for calculation output parameters in selected plots of Poland, Lithuania and Russia

Areas													
Area name		P1	P2	P3	P4	R1	R2	L1	L2	L3	L4	L5	Total
Country		Poland	Poland	Poland	Poland	Russia	Russia	Lithuania	Lithuania	Lithuania	Lithuania	Lithuania	
FID		3	2	1	0	0	1	2	4	3	1	0	
Area	km2	163	151	164	107	28	24	18	33	17	48	121	874
Average Depth	m	42	30	26	28	24	28	38	32	37	26	32	
Distance from Shore	km	41	35	11	12	11	8	52	20	16,5	11,8	31	
Power Purchase Price	EUR/kWh	0,0869	0,0869	0,0869	0,0869	0,0869	0,0869	0,0869	0,0869	0,0869	0,0869	0,0869	
		42	30	30	30	20	30	40	30	40	30	30	
Wind Speed													
		9,8	9,7	9,2	9,3	8,5	9,2	9,5	8,4	8,9	8,1	9,6	
10 m height	m/s	8,0800	8,0000	7,5900	7,6700	7,0100	7,5900	7,8300	6,9300	7,3400	6,6800	7,9200	
100 m height	m/s	9,7995	9,7025	9,2052	9,3023	8,5018	9,2052	9,4963	8,4048	8,9020	8,1016	9,6055	
Roughness Length		0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	
Weibull	Scale A	11,0579	10,9484	10,3814	10,4968	9,5615	10,3814	10,7199	9,4787	10,0429	9,1401	10,8328	
Weibull	Shape k	2	2	2	2	2	2	2	2	2	2	2	
Energy Output													
Nordex N80		1	1	1	1	1	1	1	1	1	1	1	
Capacity	kW	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	
Output	MWh												
Total	turbines	364	337	366	239	63	54	40	74	38	107	270	1952
Capacity	MW	910	842,5	915	597,5	157,5	135	100	185	95	267,5	675	4880
Output	GWh	0	0	0	0	0	0	0	0	0	0	0	0
Vestas V90		1	1	1	1	1	1	1	1	1	1	1	
Capacity	kW	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	
Output	MWh												
Total	turbines	287	266	289	189	49	42	32	58	30	85	213	1540
Capacity	MW	861	798	867	567	147	126	96	174	90	255	639	4620
Output	GWh	0	0	0	0	0	0	0	0	0	0	0	0
GE 3.6 sl		1	1	1	1	1	1	1	1	1	1	1	
Capacity	kW	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600	

Output	MWh												
Total	turbines	215	199	217	141	37	32	24	44	22	63	160	1154
Capacity	MW	774	716,4	781,2	507,6	133,2	115,2	86,4	158,4	79,2	226,8	576	4154
Output	GWh	0	0	0	0	0	0	0	0	0	0	0	0
Repower M5		1	1	1	1	1	1	1	1	1	1	1	
Capacity	kW	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	
Output	MWh												
Total	turbines	147	136	148	96	25	22	16	30	15	43	109	787
Capacity	MW	735	680	740	480	125	110	80	150	75	215	545	3935
Output	GWh	0	0	0	0	0	0	0	0	0	0	0	0

Worksheet 3. Modules for calculation number of turbines, total capacity and approximate investments; park interconnection parameters

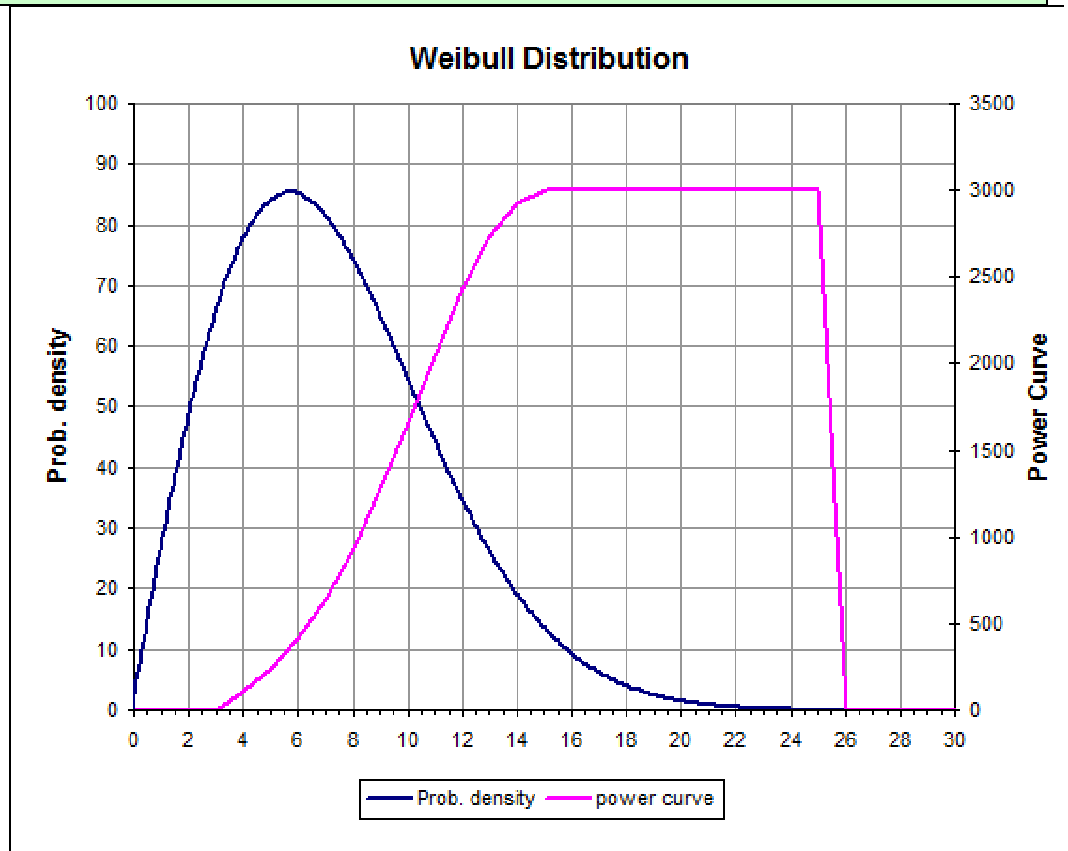
			Nordex, 2.5 MW			**Vestas, 3 MW**			**GE, 3.6 MW**			**RePower, 5 MW**		
WP name	FID	Area, km2	turbines	MW	M€	turbines	MW	M€	turbines	MW	M€	turbines	MW	M€
Poland		**585**	**1306**	**3265**	**5126**	**1031**	**3093**	**4856**	**772**	**2779**	**4363**	**527**	**2635**	**4136,95**
P1	3	163	364	910	1429	287	861	1352	215	774	1215	147	735	1154
P2	2	151	337	843	1323	266	798	1253	199	716	1125	136	680	1068
P3	1	164	366	915	1437	289	867	1361	217	781	1226	148	740	1162
P4	0	107	239	598	938	189	567	890	141	508	797	96	480	754
Russia		**52**	**117**	**293**	**459**	**91**	**273**	**429**	**69**	**248**	**390**	**47**	**235**	**368,95**
R1	0	28	63	158	247	49	147	231	37	133	209	25	125	196
R2	1	24	54	135	212	42	126	198	32	115	181	22	110	173
Lithuania		**237**	**529**	**1323**	**2076**	**418**	**1254**	**1969**	**313**	**1127**	**1769**	**213**	**1065**	**1672,05**
L1	2	18	40	100	157	32	96	151	24	86	136	16	80	126
L2	4	33	74	185	290	58	174	273	44	158	249	30	150	236
L3	3	17	38	95	149	30	90	141	22	79	124	15	75	118
L4	1	48	107	268	420	85	255	400	63	227	356	43	215	338
L5	0	121	270	675	1060	213	639	1003	160	576	904	109	545	856
Total		**874**	**1952**	**4880**	**7662**	**1540**	**4620**	**7253**	**1154**	**4154**	**6522**	**787**	**3935**	**6177,95**
Manufacturer		Nordex			Vestas			GE			Repower		
Turbine Model		**Nordex N80**			**Vestas V90**			**GE 3.6 sl**			**Repower M5**		
Rated Power	kW	2500			3000			3600			5000		
Rotor Diameter	m	80			90			104			126		
Hub Height	m	100			105			100			100		
Swept Area	m2	5026			6362			8495			12469		
Turbine Area	**km2**	**0,45**			**0,57**			**0,76**			**1,11**		

Distances between turbines		
Main Wind Direction	10	rotor D
Side Wind Direction	7	rotor D
Capital Costs per 1 MW		
Per 1 MW	M€	1,57
Distances between parks		km
P1,P2 - P3,P4	i1	82,17
P3,P4 - R1	i2	143,91
R1-R2	i3	29,37
R2-L1	i4	21,21
L1-L2	i5	29,24
L2-L3	i6	15,64
L3-L4	i7	15,37
L5-L5	i8	12,89
Total		**349,80**

Worksheet 4. Weibull distribution module

Weibull Distribution[1]

x_0=	**0**	**The parameters x_0, □and□ can be changed with □>0 and □>0**	
□ □	**8,28**		
□=	**1,97**		
E[X]=	**7,338**		
Var(X)=	**15,120**		
Std. Dev.=	**3,888**		
Mode=	**5,777**		
Med(X)=	**6,873**		
Fisher □$_1$=	**0,651**	**Right Skewed**	
Fisher □□=	**0,284**	**Steep**	
Quantiles		**Distribution function**	
r	***q_r***	***x***	***F(x)***
0,1	**2,64**	**1**	**0,01543**
0,25	**4,40**	**2**	**0,05910**
0,5	**6,87**	**3**	**0,12664**
0,75	**9,77**	**4**	**0,21231**
0,9	**12,64**	**5**	**0,30955**
(Enter other *x*-values or *r*-percentages)			



The Weibull distribution (Weibull, 1939) with three parameters, is denoted by ***W(x_0,□,□)***. It has a probability density ***f(x)=(□/□)[(x-x_0)/□]$^{□-1}$·exp{-[(x-x_0)/□]$^□$}, x>x_0***, and the distribution function equals ***F(x)=1-exp{-[(x-x_0)/□]$^□$}, x>x_0***. The Weibull distribution was initially proposed to represent the distribution of the breaking strength of materials, and nowadays it is used in reliability and quality control. Probabilities for the Weibull distribution are easily computed taking into account that the random variable ***Z=[(X-x_0)/□]$^□$*** has a standard negative exponential distribution, ***□(1)***. The standard Weibull distribution, ***W(0,1,□)*** is obtained by a location and scale transformation, ***Y=(X-x_0)/□*** (that is, ***X=□Y+x_0***) Its probability distribution equals ***f(y)=□y$^{□-1}$exp{-y$^□$}, y>0***. The moments for ***X*** are easily obtained by using the calculations for ***Y***. Note that ***□$_{rY}$=E[Y^r]= □(r/□+1)***. The quantiles are obtained from the distribution function, ***q_r=x_0+□[-ln(1-r)]$^{1/□}$***, ***0<r<1***. The median, then, takes the value, ***Me_X=x_0+□[ln2]$^{1/□}$***.

[1] Basic References: *Cálculo de probabilidades y Estadística*. H. Fernández-Abascal et al. (Ed. Ariel, Barcelona (SPAIN)1994). *Distributions in Statistics*. N.L. Johnson et al.(Vol. 1-4). (Ed. J. Wiley y Houghton M. Co., 1992, 1994, 1997). Copyright 2001 J.L. Rojo

Probability for the range not covered by the figure: ***p[X > E[X]+3□X]=***	***0,005854391***

The mode equals $\boldsymbol{Mo_X=x_0+□[(□-1)/□]^{1/□}}$ for $\boldsymbol{□>1}$, and does not exist for $\boldsymbol{□<1}$. If $\boldsymbol{□=1}$, $\boldsymbol{Mo_X=x_0}$. The skewness and the (excess of) kurtosis coefficients are computed for ***Y*** using the above expression for $\boldsymbol{□_{rY}}$

Worksheet 5. Module for calculation Wibull distribution; sample - Vestas V90

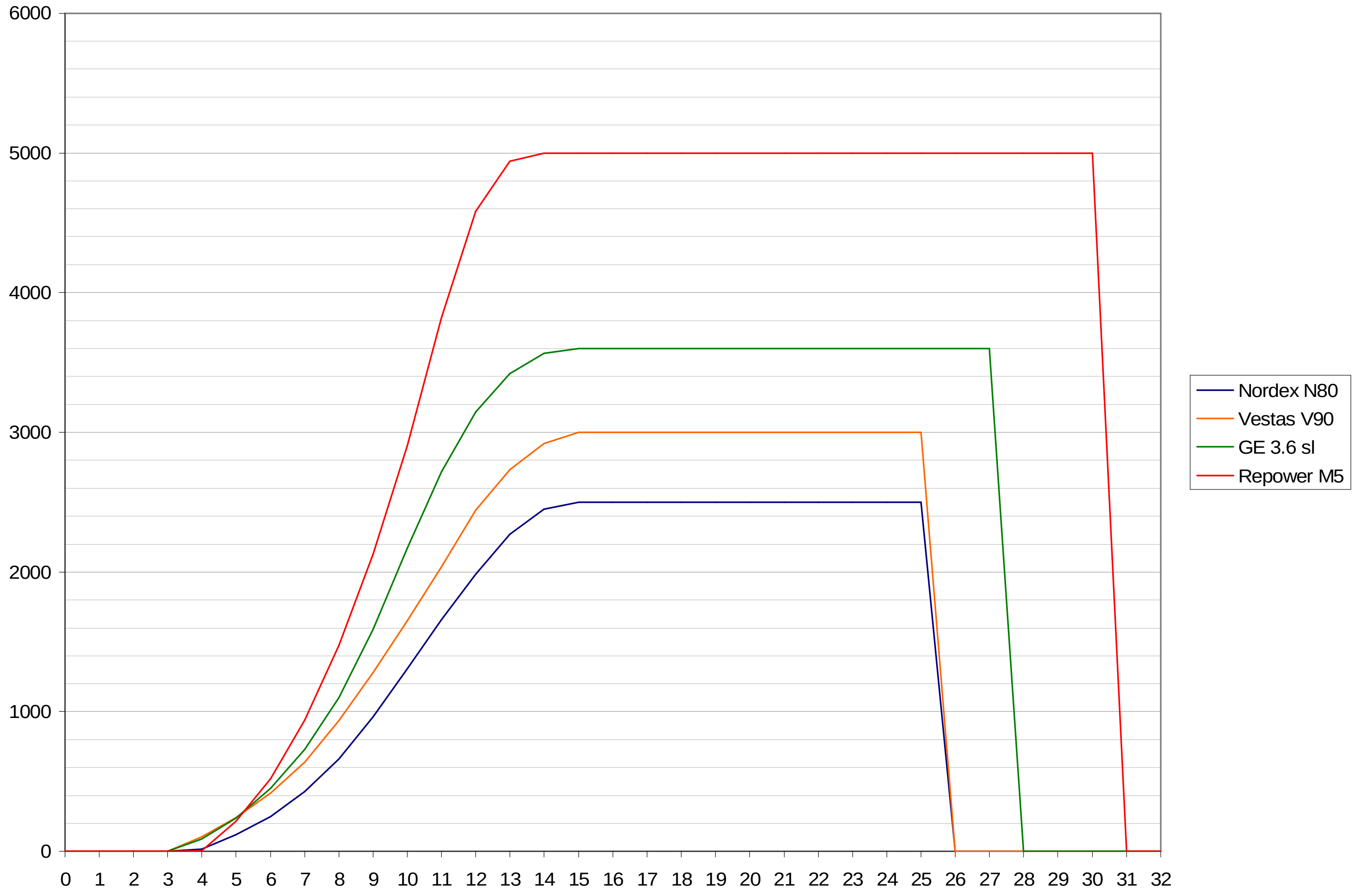
Selected Turbine				**Weibull**						Moments for Y=(X-□)/□	
										r	E[Y[r]]
Manufacturer		Vestas		Height		m	10	105		1	0,8864972
Turbine Model		Vestas V90		Roughness Length		m	0,0002	0,0002		2	1,0065341
Rated Power	kW	3000		Mean Wind Speed		m/s	6,00	7,30		3	1,3510368
Rotor Diameter	m	90		Scale parameter A			6,8	8,28		4	2,0573829
Hub Height	m	105		Shape k			1,97	1,97		$□_{2Y}$=	0,2206569
Swept Area	m2	6362		**Energy Output**		**MWh**		**8398**		$□_{3Y}$=	0,0675237
Price	EUR	3.600.000								$□_{4Y}$=	0,1598863
Wind Speed, M/s	**Power**			**Hours/Year**		**Energy Output**					
0	kW	0		hrs	38	kWh		0			
1	kW	0		hrs	249	kWh		0			
2	kW	0		hrs	514	kWh		0			
3	kW	0		hrs	643	kWh		0			
4	kW	105		hrs	844	kWh		88610			
5	kW	243		hrs	836	kWh		203209			
6	kW	417		hrs	936	kWh		390337			
7	kW	639		hrs	820	kWh		524016			
8	kW	936		hrs	828	kWh		775116			
9	kW	1283		hrs	662	kWh		849796			
10	kW	1654		hrs	616	kWh		1018718			
11	kW	2040		hrs	496	kWh		1012559			
12	kW	2441		hrs	354	kWh		864199			
13	kW	2733		hrs	295	kWh		807517			
14	kW	2921		hrs	197	kWh		575449			
15	kW	3000		hrs	154	kWh		462250			
16	kW	3000		hrs	96	kWh		289084			
17	kW	3000		hrs	71	kWh		212498			
18	kW	3000		hrs	42	kWh		124931			
19	kW	3000		hrs	29	kWh		86479			
20	kW	3000		hrs	16	kWh		47873			
21	kW	3000		hrs	10	kWh		31251			
22	kW	3000		hrs	5	kWh		16309			
23	kW	3000		hrs	3	kWh		10051			
24	kW	3000		hrs	2	kWh		4949			
25	kW	3000		hrs	1	kWh		2882			
26	kW	0		hrs	0	kWh		0			

Worksheet 6. The data of power curves of different wind turbines

Turbines

Manufacturer		Nordex	Vestas	GE	Repower	Enercon
Turbine Model		**Nordex N80**	**Vestas V90**	**GE 3.6 sl**	**Repower M5**	**E-112**
Rated Power	kW	2500	3000	3600	5000	4500
Rotor Diameter	m	80	90	104	126	
Hub Height	m	100	105	100	100	
Swept Area	m2	5026	6362	8495	12469	
Price	EUR	3.000.000	3.600.000	4.320.000	6.000.000	5.400.000
Wind Speed, M/s						
0	kW	0	0	0	0	
1	kW	0	0	0	0	
2	kW	0	0	0	0	
3	kW	0	0	0	0	
4	kW	15	105	91	4	
5	kW	120	243	240	215	
6	kW	248	417	450	520	
7	kW	429	639	732	942	
8	kW	662	936	1101	1475	
9	kW	964	1283	1591	2128	
10	kW	1306	1654	2170	2905	
11	kW	1658	2040	2717	3823	
12	kW	1984	2441	3144	4580	
13	kW	2269	2733	3420	4942	
14	kW	2450	2921	3564	5000	
15	kW	2500	3000	3600	5000	
16	kW	2500	3000	3600	5000	
17	kW	2500	3000	3600	5000	
18	kW	2500	3000	3600	5000	
19	kW	2500	3000	3600	5000	
20	kW	2500	3000	3600	5000	
21	kW	2500	3000	3600	5000	
22	kW	2500	3000	3600	5000	
23	kW	2500	3000	3600	5000	
24	kW	2500	3000	3600	5000	
25	kW	2500	3000	3600	5000	
26	kW	0	0	3600	5000	
27	kW	0	0	3600	5000	
28	kW	0	0	0	5000	
29	kW	0	0	0	5000	
30	kW	0	0	0	5000	
31	kW	0	0	0	0	

Worksheet 7. Power curves for different kind of turbines



Worksheet 8. Module for wind conditions evaluation

Wind conditions				
Wind Measurements				
Reliable Data Ratio		km		5
Covered Area		km2		79
Total Area		km2		121
Wind Analysis			1	2
Equipment		EUR	100.000	200.000
Erection		EUR	400.000	800.000
Monitoring (annual)	1	EUR	30.000	60.000
Wind Atlas		EUR	25.000	50.000
Total Wind Analysis				**1.110.000**

Worksheet 9. Module for calculation of grid connection costs

Grid connection							
						5-10 m	14%
Grid Connection Study		EUR		50.000			
Number of Turbines			1	109			
Cabeling							
Park cabeling							
Cabel length	1,3	km	1,147	124,9794			
Cable Price		EUR/km	1.200.000	149.975.280			
Construction Price		EUR/km	300.000	37.493.820			
Total Park Cabeling Price				**187.469.100**			
Substation							
Capacity		MW	5	545			
Price	1	EUR	40.000	21.800.000			
Construction Price		EUR		50.000			
Total Substation Price				**21.850.000**			
Grid Interconnection							
Distance		km		31			
Cabel length	1,5	km		46,5			
Cabel Price		EUR/km	1.200.000	55.800.000			
Construction Price		EUR/km	300.000	13.950.000			
Total Grid Interconnection Price				**69.750.000**			

Worksheet 10. Module for calculation of economic inputs

Inputs

Technical Inputs				
Area				
Turbines			**Repower M5**	
Number of Turbines			1	109
Capacity		MW	5	545
Expected Annual Output		MWh	22995	2506500
Capacity Factor		%	52,5%	52,5%
Downtime Losses	5%	MWh	1150	125325
Losses (wake and transmission)	5%	MWh	1092	119059
Net Energy for Sale		**MWh**		**2262116**
Distances				
Rotor Diameter		**m**	126	
Main Wind Direction		rotor D	10	
Side Wind Direction		rotor D	7	
Total Area		km2	1,11	121,13388
Economic Inputs				
			Lt	EUR
Currency Exchange Rate		Lt/EUR	3,4528	0,2896
Power Purchase Price		1 kWh	0,3	0,0869
		1 MWh	300	86,89
CO2 credits				
CO2 Rate		t/MWh		0,626
CO2 Price per tonn		1 t	51,79	15,00
CO2 Price per MWh		1 MWh	32,42	9,39
CO2 credits (annual)		t		**1416085**
IR		%		5,34%
Term		Years		14
Expected Inflation		%		3,0%
Power Sale Tax		%		0,0%
Income Tax		%		0,0%
Financing				
Total Capital Cost	100%	EUR		**1.160.311.010**
Debt	90%	EUR		1.044.279.909
Equity	10%	EUR		116.031.101

Worksheet 11. Module for calculation of capital costs

Capital Costs					
Number of Turbines				1	109
Development Expenses					
Wind Analysis					1.110.000
Environment Assesment Study					150.000
Bed Analysis					100.000
Grid Connection Study					50.000
Planning and Permits					100.000
Other Expenses			10%		151.000
Total Development					**1.661.000**
Equipment	**Repower M5**				
Turbines				7.000.000	763.000.000
Nacelle				Incl.	-
Towers				Incl.	-
Electrical System				Incl.	-
Monitoring System				Incl.	-
Rotor Blades				Incl.	-
Steel Towers (100 m)				Incl.	-
Foundation Drawings				Incl.	-
Shipping to Harbour				20.000	2.180.000
Warranty (2 years)				incl.	-
Total Price Turbines					**765.180.000**
Foundation				500.000	54.500.000
Shipping				5.000	545.000

Total Price Foundations				**55.045.000**
Total Price Equipment				**820.225.000**
Construction				
Foundations			200.000	21.800.000
Cabling				187.469.100
Substation				21.850.000
Grid Interconnection				69.750.000
Erection			50.000	5.450.000
Construction Insurance			10.000	1.090.000
Construction Management				200.000
Total Construction				**307.609.100**
Additional Expenses				
Development Fee				50.000
Contingency (10%)		10%		30.765.910
Total Capital Cost				**1.160.311.010**
Total Capital Cost per MW				2.129.011

Worksheet 12. Module for calculation of revenues and other economical parameters of wind power parks

Pro Forma (1000 Euro)										
Year		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
		1	2	3	4	5	6	7	8	9
Revenues										
Power Sold	MWh	2.262.1 16	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116
CO2 credits	t	141608 5	1416085	1416085	1416085	1416085	1416085	1416085	1416085	1416085
Total Revenues		217.788	217.788	217.788	217.788	217.788	217.788	217.788	217.788	217.788
Expenses										
Area Lease		109	112	116	119	123	126	130	134	138
WTG Scheduled Maintenance	1	119	122	126	130	134	138	142	146	151
Additional Maintenance Reserve		-	-	30	31	32	33	34	35	36
Site Administration (Owner)		25	26	27	27	28	29	30	31	32
Bank Fees	0,10%	218	224	231	238	245	252	260	268	276
Insurance	0,10%	820	803	785	768	752	736	720	704	689
Utilities		15	15	16	16	17	17	18	18	19
Community Compensation		10	10	11	11	11	12	12	12	13
G&A (Including 25k for Greta Admin)		60	62	64	66	68	70	72	74	76
Other Admin		10	10	11	11	11	12	12	12	13
Total Expenses		1.386	1.385	1.415	1.417	1.420	1.424	1.429	1.435	1.442
Debt Related Fees										
EBITDA		216.402	216.402	216.372	216.370	216.367	216.363	216.358	216.353	216.346
Financing										
Interest			52.986	50.058	46.975	43.727	40.305	36.701	32.904	28.904

		55.765								
Principal		5.782	6.091	6.416	6.759	7.120	7.500	7.900	8.322	8.767
P&I		61.547	59.077	56.475	53.734	50.846	47.805	44.601	41.226	37.671
Earnings before Corporate Taxes		154.855	157.326	159.898	162.637	165.521	168.559	171.758	175.127	178.675
Power Sales Tax	0%	-	-	-	-	-	-	-	-	-
Income Taxes	0%	-	-	-	-	-	-	-	-	-
Total Taxes		-	-	-	-	-	-	-	-	-
Cash after Tax		154.855	157.326	159.898	162.637	165.521	168.559	171.758	175.127	178.675
Investment Analysis										
Investment and Cash Distributions	(116.031)	154.855	157.326	159.898	162.637	165.521	168.559	171.758	175.127	178.675
PV of Levered Cash Flows at 8%	########									
Levered IRR	135,1%									
Total Capital Cost	########	216.402	216.402	216.372	216.370	216.367	216.363	216.358	216.353	216.346
PV of Unlevered Cash Flows at 8%	########									
Unlevered IRR	18,0%									
Yrs of Cash Back Unlevered	**11,0**									
Yrs of Cash Back Levered	**14,5**									
bosec	5%	10.820	10.820	10.819	10.819	10.818	10.818	10.818	10.818	10.817
		205.582	205.582	205.554	205.552	205.549	205.545	205.541	205.535	205.529
	90	1.044.2 80	838.698	633.116	427.563	222.011	16.462	(189.083)	(394.624)	(600.159)
	6%	62.657	50.322	37.987	25.654	13.321	988	(11.345)	(23.677)	(36.010)
		142.925	155.260	167.567	179.898	192.228	204.557	216.886	229.212	241.538
		838.698	633.116	427.563	222.011	16.462	(189.083)	(394.624)	(600.159)	(805.687)
years	5	1	1	1	1	1	0	0	0	0

2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
10	11	12	13	14	15	16	17	18	19	20
2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116	2.262.116
1416085	1416085	1416085	1416085	1416085	1416085	1416085	1416085	1416085	1416085	1416085
217.788	217.788	217.788	217.788	217.788	217.788	217.788	217.788	217.788	217.788	217.788
142	146	151	155	160	165	170	175	180	186	191
155	160	164	169	174	180	185	191	196	202	208
37	38	39	40	42	43	44	45	47	48	50
33	34	35	36	37	38	39	40	41	43	44
284	293	301	311	320	329	339	349	360	371	382
674	660	646	632	618	605	592	579	567	555	543
20	20	21	21	22	23	23	24	25	26	26
13	13	14	14	15	15	16	16	17	17	18
78	81	83	86	88	91	93	96	99	102	105
13	13	14	14	15	15	16	16	17	17	18
1.449	1.458	1.468	1.479	1.490	1.503	1.517	1.532	1.548	1.566	1.584
216.338	216.329	216.320	216.309	216.297	216.284	216.270	216.255	216.239	216.222	216.203
24.691	20.253	15.578	10.653	5.465	-	-	-	-	-	-
9.235	9.728	10.247	10.794	11.371	-	-	-	-	-	-
33.926	29.981	25.825	21.447	16.836	-	-	-	-	-	-
182.413	186.349	190.495	194.862	199.461	216.284	216.270	216.255	216.239	216.222	216.203
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
182.413	186.349	190.495	194.862	199.461	216.284	216.270	216.255	216.239	216.222	216.203

182.413	186.349	190.495	194.862	199.461	216.284	216.270	216.255	216.239	216.222	216.203
216.338	216.329	216.320	216.309	216.297	216.284	216.270	216.255	216.239	216.222	216.203
10.817	10.816	10.816	10.815	10.815	10.814	10.814	10.813	10.812	10.811	10.810
205.521	205.513	205.504	205.493	205.482	205.470	205.457	205.442	205.427	205.411	205.393
(805.687)	(1.011.208)	(1.216.721)	(1.422.225)	(1.627.719)	(1.833.201)	(2.038.671)	(2.244.127)	(2.449.570)	(2.654.997)	(2.860.408)
(48.341)	(60.673)	(73.003)	(85.334)	(97.663)	(109.992)	(122.320)	(134.648)	(146.974)	(159.300)	(171.624)
253.862	266.185	278.507	290.827	303.145	315.462	327.777	340.090	352.401	364.711	377.018
(1.011.208)	(1.216.721)	(1.422.225)	(1.627.719)	(1.833.201)	(2.038.671)	(2.244.127)	(2.449.570)	(2.654.997)	(2.860.408)	(3.065.801)
0	0	0	0	0	0	0	0	0	0	0