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The Effect of Wind Speed and Electric Rates On Wind Turbine Economics

Economics of wind power

This is an introduction to the economics of community-scale wind power projects. Wind energy projects are highly sensitive to many factors – particularly wind speed, and its close relative, capacity factor. First, start with two definitions.

Definition: Capacity Factor

"Capacity Factor" is equal to the annual energy production divided by the theoretical maximum energy production if the generator were running at its rated power all the year. For example, if a 1500 kW machine makes 3.5 million kWh in a year, that's $3,500,000 / (365 * 24 * 1500) = 27\%$ capacity factor. (See [Fact Sheets](#) on RERL's website for more on Capacity Factor.)

Your capacity factor depends mainly on the wind speeds and the turbine make and model.

Definition: Simple Payback

The "Simple Payback" time of a project is found by taking the initial cost of putting a machine in, and dividing by the annual net income. It is a simple indicator of how long it takes to get out the money you put in. It does not reflect the cost of money.

Example

The following page outlines a simple example of the simple payback period of a small wind power project. All the figures are *per turbine*, so it can be used for a one, two or three-turbine project.

This simplified example is intended only for illustrative purposes. It includes many assumptions for costs, revenues, turbine size, etc. – your case will be different. This short document does not tell you *what* these costs will be, but gives you a framework to estimate project payback – once you have evaluated all the assumed values for your particular case. The following notes apply:

1. *Net Annual income (line T) is NOT profit! It is an estimate of income after operating expenses, but before the cost of capital, interest, etc.. That is, this would be the money that is used to pay for the capital equipment plus interest - and hopefully, some profit ultimately as well.*
2. *Land lease payments, if any, can be included in the annual cost (line S)*
3. *All figures are per turbine, yet costs will vary based on the number of turbines in a project*
4. *Since the federal tax credit lasts only 10 years, any examples showing a simple payback of over 10 years falsely inflates the annual revenue afterwards.*

What to notice in the example - Ways to reduce the payback time:

1. Raise Production (line E) – make more energy (kWh), i.e., better capacity factor: find higher wind speeds, use a taller tower, a better site, a different turbine.
2. Raise Revenue (line P) – get better value for your kWh: use more power on-site.
3. Lower Costs (line V) – keep installation cost/kW down: put in more turbines, chose a simpler site.

Example The economics of a wind power project depends on many factors. Here is a simple example using some broad assumptions:

			<i>How to figure</i>	<i>Value</i>	<i>Units</i>
A	1. Production	Capacity factor:		28.0%	
B	<i>per turbine</i>	Rated Power per turbine:	<i>assumption</i>	1,500	kW
C		Availability	<i>assumption</i>	97%	
D				8,760	hrs/year
E		Annual Energy Production	$E = A*B*C*D$	3,568,824	kWh/year
G	2. Revenue	Energy used on-site (%)	<i>assumption</i>	50%	
H	<i>per turbine</i>	Your electricity price	<i>from your utility bill</i>	\$0.150	\$/kWh
J		Energy price (when sold wholesale)	<i>assumption</i>	\$0.050	\$/kWh
K		Energy value	$K = G*H + (1-G)*J$	\$0.100	\$/kWh
L		Massachusetts RPS (REC's)	<i>assumption</i>	\$0.030	\$/kWh
M		Federal tax credit (PTC) (1 st 10 years only)	<i>assumption</i>	\$0.019	\$/kWh
N		Revenue Rate, Gross (per kWh)	$N = K + L + M$	\$0.149	gross rev/kWh
P		Estimated Annual revenue	$P = E*N$	\$531,755	gross \$/yr
R	3. Costs	Maintenance & insurance (rate)	<i>assumption</i>	\$0.015	\$/kWh
S	<i>per turbine</i>	Annual costs	$S = E*R$	\$53,532	\$/year
T		Estimated annual income*	$T = P - S$	\$478,222	net \$/yr
U		Estimated installed cost/ MW	<i>assumption</i>	2,000	\$/kW
V		Estimated installed cost	$V = B*U$	\$3,000,000	installed cost
W	4. "Simple Payback" period, per turbine*		$W = T/V$	6	years

Important ways to reduce payback time

Using all the above assumptions, we can estimate "Simple Payback" as a function of capacity factor and revenue rate for this example case. The purpose of this table is not to show payback – your results will vary – but rather to illustrate the importance of wind speed (left column) and on-site loads (top row) to the economics of community-scale wind power.

Cap. Factor:	kWh/year	Gross revenue rate per kWh for this example project:																
		5 ¢	6 ¢	7 ¢	8 ¢	9 ¢	10 ¢	11 ¢	12 ¢	13 ¢	14 ¢	15 ¢	16 ¢	17 ¢	18 ¢	19 ¢	20 ¢	21 ¢
18%	2,294,244	37	29	24	20	17	15	14	12	11	10	10	9	8	8	7	7	7
20%	2,549,160	34	26	21	18	16	14	12	11	10	9	9	8	8	7	7	6	6
22%	2,804,076	31	24	19	16	14	13	11	10	9	9	8	7	7	6	6	6	5
24%	3,058,992	28	22	18	15	13	12	10	9	9	8	7	7	6	6	5	5	5
25%	3,186,450	27	21	17	14	13	11	10	9	8	8	7	6	6	5	5	5	5
26%	3,313,908	26	20	16	14	12	11	10	9	8	7	7	6	6	5	5	5	5
27%	3,441,366	25	19	16	13	12	10	9	8	8	7	6	6	6	5	5	5	4
28%	3,568,824	24	19	15	13	11	10	9	8	7	7	6	6	5	5	5	5	4
29%	3,696,282	23	18	15	12	11	10	9	8	7	6	6	6	5	5	5	4	4
30%	3,823,740	22	17	14	12	10	9	8	7	7	6	6	5	5	5	4	4	4
31%	3,951,198	22	17	14	12	10	9	8	7	7	6	6	5	5	5	4	4	4
32%	4,078,656	21	16	13	11	10	9	8	7	6	6	5	5	5	4	4	4	4
33%	4,206,114	20	16	13	11	10	8	8	7	6	6	5	5	5	4	4	4	4
34%	4,333,572	20	15	13	11	9	8	7	7	6	6	5	5	4	4	4	4	4
35%	4,461,030	19	15	12	10	9	8	7	6	6	5	5	5	4	4	4	4	3
36%	4,588,488	19	15	12	10	9	8	7	6	6	5	5	5	4	4	4	4	3
38%	4,843,404	18	14	11	10	8	7	7	6	5	5	5	4	4	4	4	3	3

* Many assumptions go into these examples.