



# Micro Wind Turbines (MWTs)

George Randolph

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# Wind Power

$$\text{Wind Power} = 0.5 \cdot c_p \cdot \rho \cdot v^3$$

# Capacity Factor

$$C_p = \frac{\text{annual turbine energy output}}{365.25 \text{ days} \cdot 24 \text{ hours} \cdot \text{rated output}}$$

- Determine percentage of electricity generated from MWT
- Derive BAU forecast from AMPERE database with the MWT percentage and capacity factor



### Forecasts

Year	2014 SWWR	2015 SWWR	GCAM SOP Derived	RRS SOP Medium
2009	50	50	170	
2010	80	80	200	
2011	100	100	240	
2012	120	120	280	
2013	180	100	320	
2014	220	120	360	
2015	310	120	400	210
2016	360	160	440	260
2017	410	190	490	310
2018	510	220	530	370
2019	610	260	580	440
2020	770	310	630	520

# Results

Metric	Value
Max Annual Emissions Reduction	0.08 Gt CO <sub>2</sub> /yr
<b>Total Emissions Reduction (2015-2045)</b>	<b>0.8 Gt CO<sub>2</sub></b>
Approximate ppm equivalent (2015-2045)	0.07 ppm CO <sub>2</sub> eq
Approximate ppm equivalent (2045)	0.06 ppm CO <sub>2</sub> eq
Approximate ppm Rate of Change in 2045	0.007 ppm CO <sub>2</sub> -eq
Cumulative First Cost	\$322 B
Marginal First Cost	\$209 B
Cumulative Net Cost Savings	\$300 B
Global Units Installed by 2045	60 M kW
<b>Lifetime Savings</b>	<b>\$1.2 T</b>
Lifetime Savings NPV	\$12 B



# Results

Metric	MWT	Total Wind
Max Annual Emissions Reduction	0.08 Gt CO2/yr	3.27 Gt CO2/yr
<b>Total Emissions Reduction (2015-2045)</b>	<b>0.8 Gt CO2</b>	<b>42 Gt CO2</b>
Approximate ppm equivalent (2015-2045)	0.07 ppm CO2 eq	3.63 ppm CO2 eq
Approximate ppm equivalent (2045)	0.06 ppm CO2 eq	3.36 ppm CO2 eq
Approximate ppm Rate of Change in 2045	0.007 ppm CO2-eq	0.27 ppm CO2-eq
Cumulative First Cost	\$322 B	\$4.4 T
Marginal First Cost	\$209 B	\$4 T
Cumulative Net Cost Savings	\$300 B	\$6.9 T
Global Units Installed by 2045	60 M kW	3 B kW
<b>Lifetime Savings</b>	<b>\$1.2 T</b>	<b>\$10.7 T</b>
Lifetime Savings NPV	\$12 B	\$268 B

# Wind Speed Sensitivity

Metric	26% CF	47% CF
Max Annual Emissions Reduction	0.08 Gt CO2/yr	0.14 Gt CO2/yr
<b>Total Emissions Reduction (2015-2045)</b>	<b>0.8 Gt CO2</b>	<b>1.3 Gt CO2</b>
Approximate ppm equivalent (2015-2045)	0.07 ppm CO2 eq	0.12 ppm CO2 eq
Approximate ppm equivalent (2045)	0.06 ppm CO2 eq	0.11 ppm CO2 eq
Approximate ppm Rate of Change in 2045	0.007 ppm CO2-eq	0.012 ppm CO2-eq
Cumulative First Cost	\$322 B	\$322 B
Marginal First Cost	\$209 B	\$211 B
Cumulative Net Cost Savings	\$300 B	\$534 T
<b>Lifetime Savings</b>	<b>\$1.2 T</b>	<b>\$2.1 T</b>
Lifetime Savings NPV	\$12 B	\$51 B



# Discussion

- Good interstitial solution
- Great for remote locations
- Room for experimentation
- Higher cost than utility-scale wind
- Lower capacity and longer payback period