WindCheck

Project ID: CA100302
Project Name: Shelter Island
Prepared For: Alan Hertner
Date Prepared: Oct 18, 2010

Executive Summary

This report has been commissioned by Mr. Alan Hertner of Island Marina, which wants to investigate the feasibility of using wind power to provide electricity to a new storage building being constructed at the dock facility located at the west end of Shelter Island. The maximum available budget for the project is $100,000, and the estimated electrical load for this building is 15,000 kwh per year. The target location for the turbine is 32.70807°N, 117.23401°W.

Based on the client's input, this report is prepared for a small wind system with the following nominal characteristics:

Rated Nameplate Capacity:	10kw
Rated Wind Speed:	28 mph
Annual Energy Output (10 mph)	27,600 kwh
Tower height	40 meters (131 feet)
Total Installed Cost	$90,000
Total Incentives	$19,000
Net System Cost	$71,000

Smallwind.com conducted detailed meteorological analyses of the winds at the target site, using the 31 year NARR data set and incorporating appropriate geographic, topographic, and site specific factors. Based on those analyses, the 40m winds can be characterized as follows:

Raw Average Wind Speed	11.6 mph
Effective Average Wind Speed	9.7 mph

Smallwind.com then conducted an economic analysis to estimate the energy generated by these winds, the monetary value of that energy, and the payback period, cost per kwh, and project suitability, with the following results:

Average Annual Energy Generation	26,450 kwh
Average Annual Energy Cost Savings	$5,750
Payback period	12.0 years
Cost per kwh	7.5 cents/kwh

Clients who are interested in a more detailed assessment can schedule a WindCheck Plus analysis. This analysis starts with an on-site visit by a certified wind assessor, allowing direct examination of nearby obstructions to the wind and a customized evaluation of installation costs for the target location. See the smallwind.com web site for more details and ordering information.

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Note: the data shown in this sample report does not represent the actual conditions in the designated location. It is presented for illustrative purposes only and should not be used for actual planning of a small wind system installation.

WindCheck Methodology

The WindCheck process begins with wind and weather data extracted from the North American Regional Reanalysis (NARR), a historical weather data set generated by meteorologists and computer modelers from the National Center for Atmospheric Research (NCAR) and the National Centers for Environmental Prediction (NCEP). The NARR project has generated an extended data set covering the 31 year period from 1979 to 2009, merging the results of advanced computer modeling with real world weather and wind readings taken across North America.

The resulting NARR data set is one of the most comprehensive and sophisticated long term historical weather and wind data sets in existence and provides an unequaled wealth of data that can be used for the analysis of winds for small wind projects. At the same time, because of the area and time period covered, the NARR is limited to a relatively coarse 32 km horizontal resolution. This resolution is sufficient for capturing large scale physical features and the resulting weather patterns, but it does not satisfactorily capture the medium and small scale features that can have a significant impact on the wind resource at a particular location.

With this in mind, the meteorologists at smallwind.com have designed the WindCheck process specifically to account for those features. In the first step, medium scale geographic and topographic features are incorporated, like the presence of hills, valleys, or large bodies of water (all of which can affect the wind speed, direction, and the amount of turbulence).

An initial review is done to examine the directionality of the winds at the target location. If there is flexibility in exactly where the small wind system will be installed, this step also allows the identification of the optimum location.

In the second step, the small scale site specific features found at the target location are accounted for. These features (like buildings, trees, and other obstructions) can have a significant effect on the amount and quality of wind available to power a small wind system, and must be taken into account if an accurate assessment is to be conducted.

During these two steps, WindCheck uses the results of the geographic, topographic, and site specific analyses to adjust the NARR historical wind record to more accurately represent the wind conditions found at the target location. That adjusted historical wind record is then used to create an estimate of the wind energy generated by those winds.

WindCheck then applies the local price of electricity to calculate the monetary value of the energy generated by the wind. Finally, an economic analysis balances those costs savings against the costs of installing a small wind system, providing figures for payback period and cost-per-kilowatt-hour.

Overall, the WindCheck report provides you with the industry's only top-to-bottom project assessment. With world-class meteorological analysis, realistic energy and cost projections, and unbiased analysis, smallwind.com's WindCheck helps you make your best decision about a small wind project.

Assumptions and Conventions

Turbine Height

It is well understood that wind speed increases the higher up one goes in the Earth's atmosphere. Moreover, the further one gets from the rough features found on the surface (both natural and man-made), the less the amount of turbulence encountered in the wind (turbulence acts to increase wear and tear on the mechanical components of a small wind turbine and to reduce its efficiency at generating electricity).

Due to both of these factors, accepted practice in the wind energy industry is to place the turbines as high in the atmosphere as is cost effective and practical from an engineering perspective. This optimizes the efficiency, effectiveness, reliability, and durability of the system and yields the best economic return.

Towers for small wind turbines range from 10 meters to as high as 50 meters. This WindCheck report provides data for a nominal installation height of 40 meters, which is close to the heights of towers offered by a variety of manufacturers. However, in some of the discussions, results for other tower heights are provided in order to give the reader for a feel for the balance between the costs and benefits of additional height.

Wind Direction

The convention in the meteorological and wind energy communities is to refer to the wind using the direction it is *coming from*. Thus, a "North wind" is one that where the winds are coming from the North.

For simplicity and clarity, the WindCheck report divides the compass rose into 8 sectors: North (N), Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), West (W), and Northwest (NW).

Effective Average Wind Speed

The industry standard in meteorological and wind resource assessment studies is to provide and use average wind speeds to characterize the wind resource and estimate the energy production from that resource. However, because the wind varies around the average wind speed and the wind energy generated does not vary linearly with wind speed (and is zero below the Cut In wind speed), the use of the raw average wind can be misleading and lead to inaccurate results.

To overcome this limitation, smallwind.com uses Effective Average Wind Speed instead of the raw average wind speed. Effective Average Wind Speed can be defined as the wind speed that would have to blow *steadily* for a specified period of time to produce a specified amount of energy. It can only be calculated through the use of an actual wind history, not from a single average wind value.

To calculate the Effective Average Wind Speed, the variable wind history is used to create an analogous energy generation history. That energy generation history is then summed and divided by the period of time over which it was generated, yielding an average energy generation rate. The wind power equation can then be used to solve for the steady wind speed that would generate that specified amount of energy.

Nominal Small Wind System Prices

The WindCheck economic analysis uses the nominal small wind system prices shown in Figure 1 below. These prices are obviously very broad brush and the actual prices will vary greatly based on a number of factors. However, these prices are based on inputs from highly experienced small wind dealers and installers and are accurate enough to support the first look, remote assessment carried out in the WindCheck process.

Small Wind System Rated Power	Total Cost Includes Turbine, Balance of System, Tower, and Installation
100 kw	$550,000
50 kw	$350,000
10 kw	$90,000
5 kw	$55,000
1 kw	$13,000

Figure 1 - Nominal Small Wind System Total Installed Costs

More refined cost estimates, tailored to a specific small wind system and the client's target location, are available in the follow-on WindCheck Plus analysis.

Service Life

The small wind turbine system life is assumed to be 20 years. Note that many systems, with proper maintenance, can have effective lives well beyond this.

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Step 1 - Geographic and Topographic Analysis

In this step, the smallwind.com analyst catalogs the medium scale geographic and topographic features that are found near the target location. The WindCheck software then takes the results of that analysis, applies them to the large-scale wind record provided by the NARR, and generates an adjusted medium-scale wind profile.

Figures 2 and 3 provide satellite views of the area around the target location.

Figure 2 - Satellite View (wide)

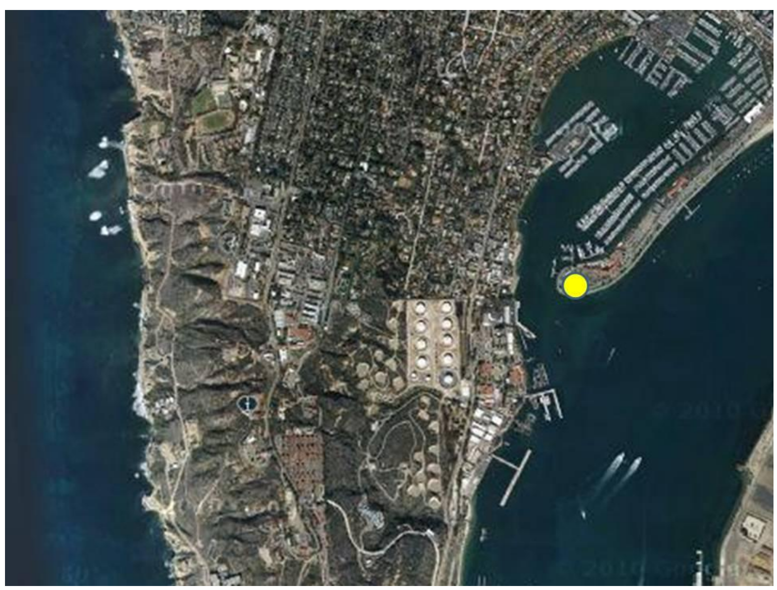

Figure 3 - Satellite view

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Figure 4 shows the topography found in the vicinity of the target location.

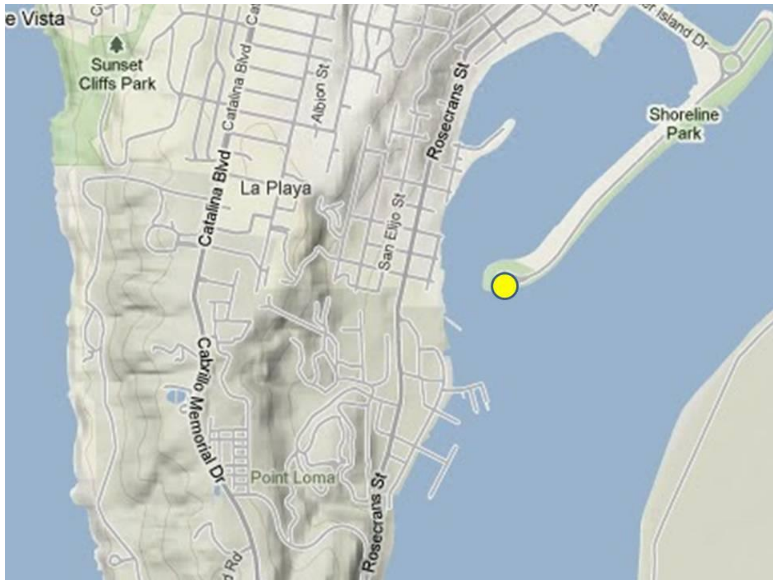


Figure 4 - Topographic view

To the South of the target location, the Pacific Ocean shoreline runs roughly East to West, resulting in a North-South land and sea breeze pattern, which will dominate the wind flows on many warmer days. There is also a North-South oriented shoreline located approximately 1.5 miles to the west, but there is significant terrain in place to block that flow, so the shoreline to the South provides the major land and sea breeze component. The three ridge lines found to the Southwest, West, and Northwest also have some impact, varying from slight to significant, on the winds from the directions indicated. These features and their impacts are summarized in Figure 5.

Feature	Distance and Direction	Effect on winds
Pacific Ocean	2.5 miles to S	land/sea breeze
400 ft ridge	0.8 miles to SW	moderate obstruction
360 ft ridge	0.4 miles to W	significant obstruction
240 ft ridge	0.6 miles to NW	slight obstruction

Figure 5 - Summary of Geographic and Topographic Features

Step 1 Results - Wind Directionality

The WindCheck software takes the effects of the identified geographic and topographic features, applies them to the 31 year NARR wind record, and generates an adjusted medium scale wind record. This intermediate data set is used to examine the directionality of the wind, which has a significant impact on the amount of wind that can eventually be converted successfully into wind energy.

Figure 6 provides a summary of the medium scale winds by direction and speed. For winds that are below the Cut In speed, direction is not important, so they are lumped together into a single category, marked by the red bar.

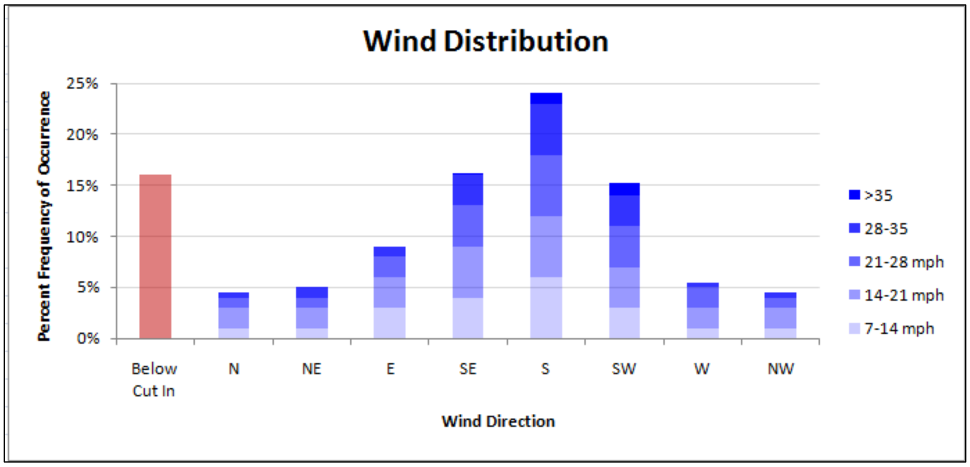


Figure 6 - Summary of 40m Medium Scale Wind Record

For the target location, the winds are seen to flow most frequently from the Southeast, South, and Southwest. This includes the strongest and most productive winds (indicated by the darker shades of blue) and reflects the strong influence of the southerly onshore sea breeze.

This directionality is an important consideration as the process moves into the site specific analysis, since any obstructions in these directions will have a significant effect on the amount of wind reaching the small wind turbine, and therefore on the amount of wind energy generated. If there is flexibility in exactly where the small wind system can be installed, the focus should be on minimizing the obstructions in the predominant directions.

In this case, a preliminary review of obstructions near the target location (to be examined in more detail in the next step) indicates that there are no significant obstructions in the predominant directions. As a result, there is no need to adjust the target location.

Step 2 - Site Specific Analysis

After the geographic and topographic analysis is completed and incorporated into the medium scale wind record, the smallwind.com analyst then reviews and catalogs the smaller scale site specific conditions found in the immediate vicinity of the target location. These buildings, vegetation, and other obstructions have a significant effect on the wind speed and turbulence at the target location. This analysis is conducted using data from various geographic information systems and documentation provided by the client.

For this step, the area around the target location has been divided into eight sectors, as seen in Figure 7.

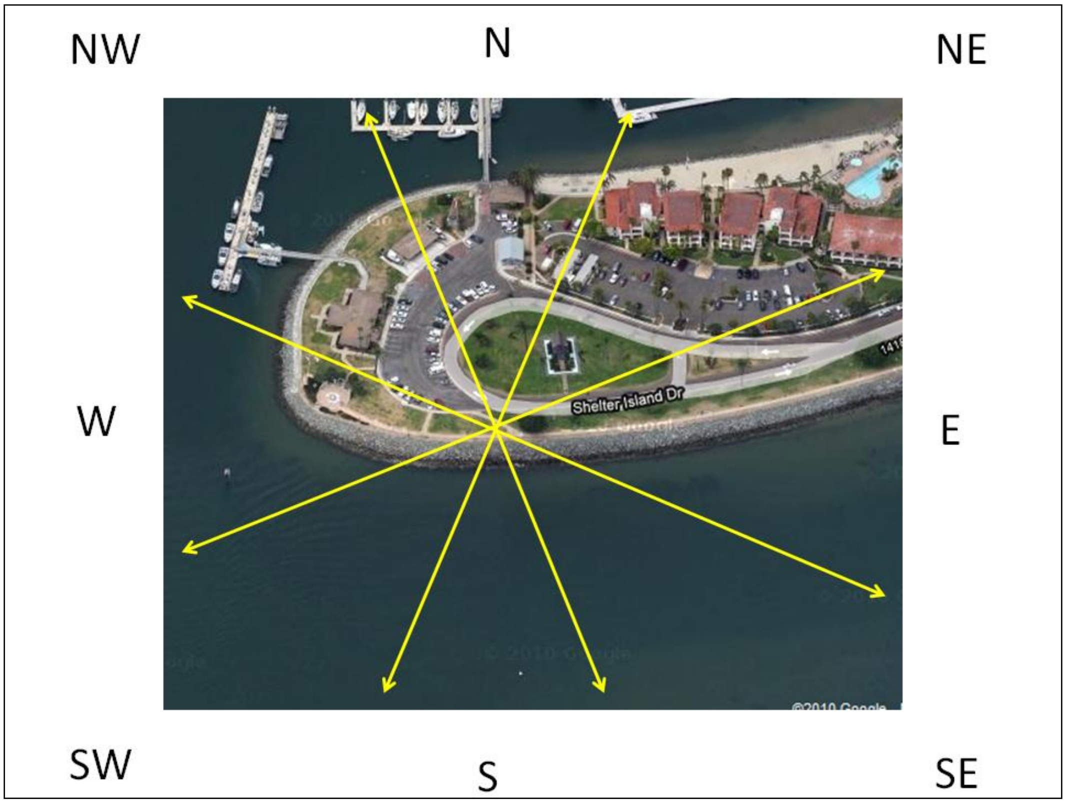


Figure 7 - Small scale satellite view with sectors

Each sector is then examined in turn, characterizing the surface roughness and looking for obstructions to the wind, as well as other factors that might complicate installation or operation of a small wind turbine. Figure 8 provides a summary of the results for each sector, with the primary obstructions being the buildings that are located to the North and Northeast of the target location.

While an ideal installation would have clear ground in all directions, these buildings are not expected to have a large impact on the wind energy generation at this site because the major energy generating winds come from the Southeast through Southwest.

North

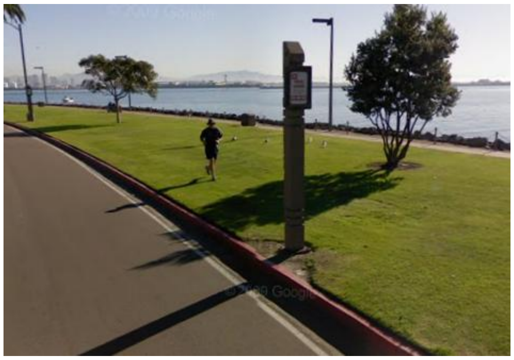
Looking to the North, there are several 1 story buildings and a 3 story navigation aid at a distance of 300 ft. Beyond that is open water for approximately 2000 ft, then medium density 1-3 story buildings located on a small ridge in the distance.

Roughness Category: High

Northeast

Looking to the Northeast, the primary factors are a 1 story pagoda and scattered palm trees at a distance of 50 to 200 ft and 2-3 story buildings at a distance of 300 to 800 ft. Beyond that is a boat marina for approximately 2000 ft, then open water.

Roughness Category: Very High



East

Looking to the East, there are no significant obstructions other than a few scattered trees, with over 5000ft of open water beyond that.

Roughness Category: Low

Southeast

Looking to the Southeast, there are no significant obstructions other than a few scattered trees, with over 5000 ft of open water beyond that.

Roughness Category: Low

Figure 8 - Small Scale analysis of obstructions by Sector

South

Looking to the South, there are no obstructions, with over 5000 ft of open water.

Roughness Category: Very Low

Southwest

Looking to the Southwest, there is over 800 ft of open water, with a dock and light industrial complex beyond that.

Roughness Category: Low-Moderate

West

Looking to the West, there is approximately 400 ft of open water, with medium density commercial and residential buildings beyond that.

Roughness Category: Moderate-High

Northwest

Looking to the Northwest, there is a 1 story building at a distance of 150 ft, with a small dock complex, 500 ft of open water, and medium density 1-3 story buildings beyond that.

Roughness Category: High

Figure 8 - Small Scale analysis of obstructions by Sector (cont.)

Note: the data shown in this sample report does not represent the actual conditions in the designated location. It is presented for illustrative purposes only and should not be used for actual planning of a small wind system installation.

Step 2 Results - Wind Speeds

The obstructions identified during the Site Specific analysis and listed in Figure 8 are then used to further adjust the medium scale wind record that was generated after the geographic and topographic analysis. This yields a new, small scale wind record that incorporates the effects of the obstructions found at the site, which will often have a significant impact on the winds available to power a small wind turbine. This small scale wind record is shown in Figure 9. Multiple tower heights are displayed in order to illustrate the differences in wind speeds by height.

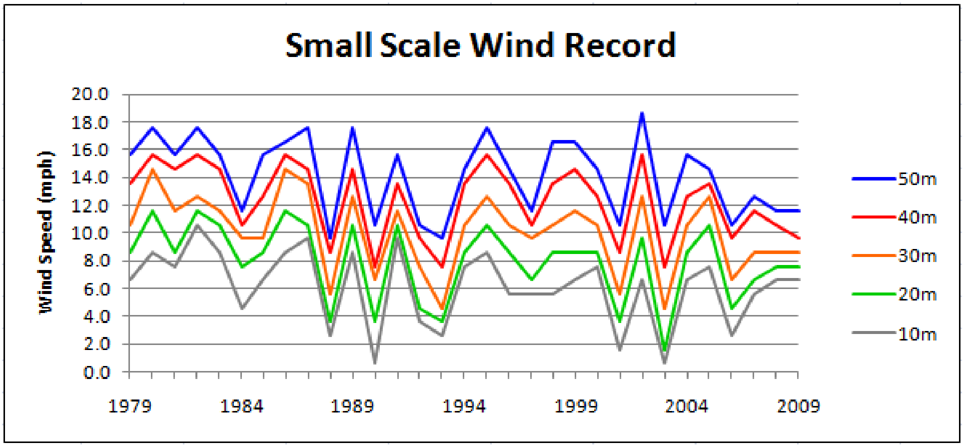


Figure 9 - Small Scale Wind Record

From these long term small scale wind records, the raw average winds speeds and the Effective Average Wind Speeds are then calculated, and are presented in Figure 10. Values for multiple tower heights are provided to illustrate the differences with height.

Type of Average Wind Speed	Tower Height				
	10m	20m	30m	40m	50m
Raw Average Wind Speed (mph)	5.3	7.6	9.7	11.6	13.5
Effective Average Wind Speed (mph)	4.8	6.1	8.5	9.7	11.8

Figure 10 - Small Scale Wind Record Averages

Step 2 Results - Wind Variability

To give an indication of how wind conditions will vary over time, the 31 year small scale wind record is then analyzed statistically to quantify how the winds vary over specified periods of time. Figure 11 shows the highest and lowest 1-month and 1-year periods found in the 31 year wind record. Figure 12 shows how the 40m winds vary by the time of year, while Figure 13 shows how the 40m winds vary by the time of day.

Period of Interest	Dates	Effective Average Wind Speed (mph)
Highest-1 Month Period	Oct 2002	14.0
Highest-1 Year Period	2002	11.7
Lowest 1-Month Period	Dec 2003	6.2
Lowest 1-Year Period	2002-2003	7.3

Figure 11 - Highest and Lowest Months and Years for 40m winds

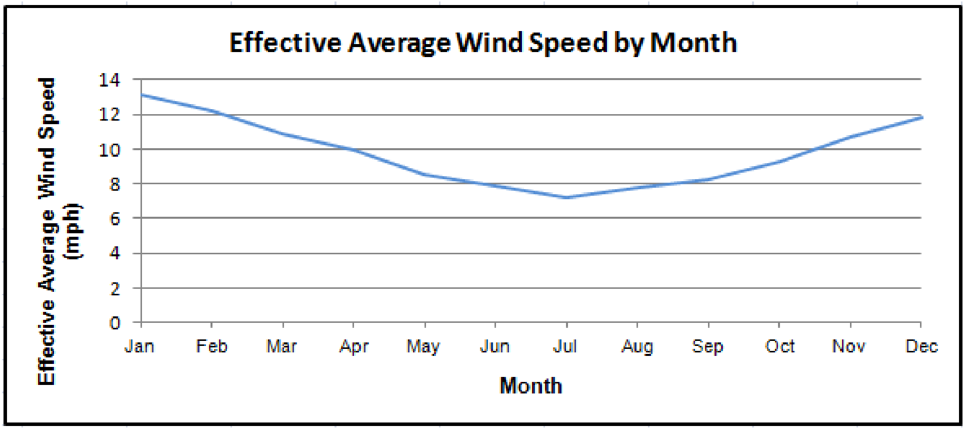


Figure 12 - Effective Average Wind Speed by Time of Year

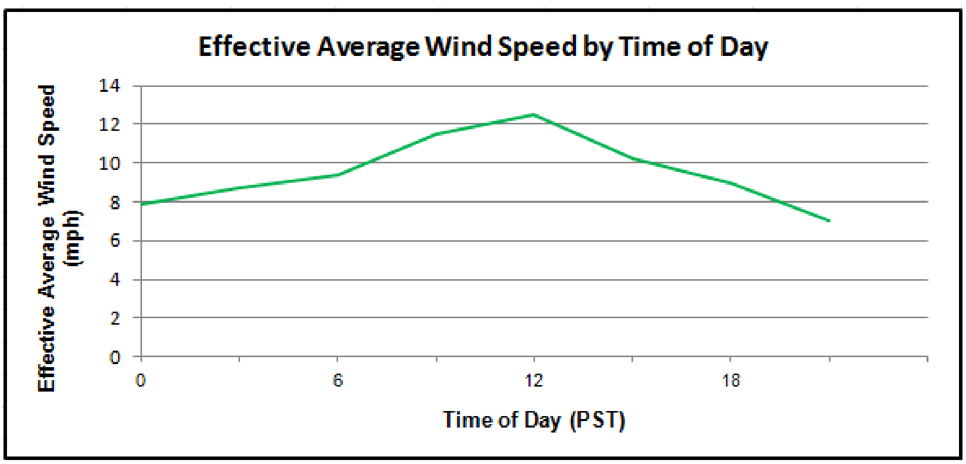


Figure 13 - Effective Average Wind Speed by Time of Day

These analyses of variation are useful in helping a small wind system owner be aware of outlier events and understand how their wind energy generation will align with their electrical load, which varies by both season and time of day.

Step 3 - Economic Analysis

In the third step, the WindCheck software takes the small-scale wind record, uses a generalized power curve to estimate the generation of electricity by the small wind system, and then uses that energy output to calculate an electricity cost savings estimate. That cost savings is then compared to the price of installing a small wind system to examine the economic return on investment of the small wind system.

Energy Generation

Figure 14 shows estimated energy generation over the course of the 31 year small-scale wind record for the nominal 10kw turbine. In order to illustrate the impact of height on energy generation, the figure includes the energy generation at the 3 nominal tower heights that are practical for a 10kw turbine.

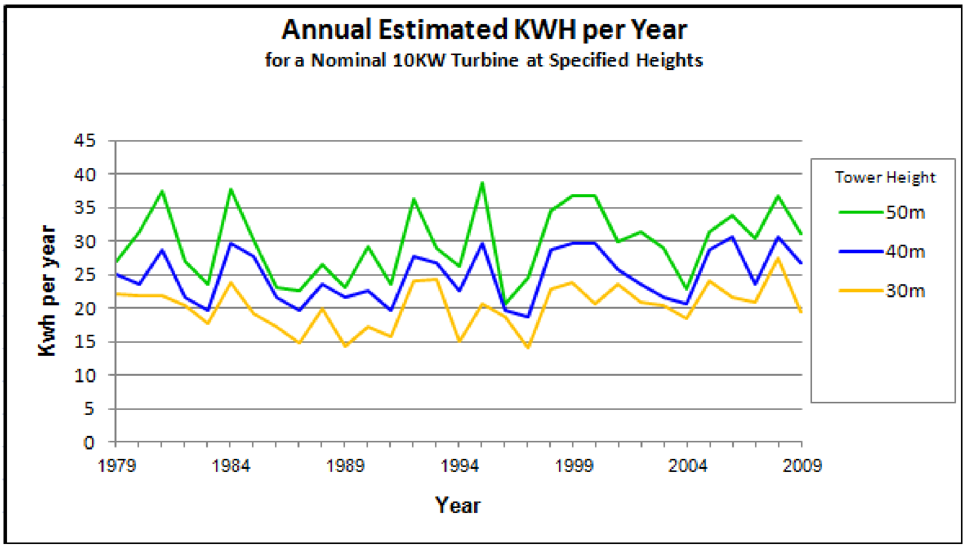


Figure 14 - Annual Estimated Energy Generated

Energy Cost Savings

Following that, the WindCheck software applies the current price of electricity in the San Diego region (18 cents per kwh) to calculate the cost savings associated with the small wind system. This time series is then analyzed to calculate the average annual cost savings, as well as the best and worst one month and one year periods. These results are shown in Figure 15 for the three designated tower heights.

Type of Energy Cost savings	Tower Height				
	10m	20m	30m	40m	50m
Average Annual	N/A	N/A	$5180	$5750	$6490
Best 1 month	N/A	N/A	$785	$820	$960
Best 1 year	N/A	N/A	$7140	$7760	$8120
Worst 1 month	N/A	N/A	$235	$270	$305
Worst 1 year	N/A	N/A	$3720	$3960	$4150

Figure 15 - Average annual, best, and worst energy cost savings.

System Net Cost

Currently, there are a variety of incentives in place to spur the installation of small wind and other renewable energy systems. These incentives include tax credits, grants, rebates, and loans. Present value calculations allow these incentives to be consolidated as if they were being applied in a single year, in order to allow a simple and straightforward calculation.

Applying these federal, state, and local incentives reduces the nominal cost of a 10kw system by approximately $19,000, yielding a system net cost of $71,000.

Payback Period and Cost per Kilowatt-Hour

Using the average annual energy savings and the system net costs (a small adjustment is made to reflect the cost of varying tower heights), the WindCheck software then calculates the payback period for the designated 10kw small wind system. Using the assumed 20 year operating life, the WindCheck software also calculates the cost per kwh over the life of the system, which allows the client to compare the cost of electricity produced by a small wind system versus the cost of electricity purchased from the local provider. These results are shown in Figure 16.

Economic Factor	Tower Height				
	10m	20m	30m	40m	50m
Small Wind System Net Cost	N/A	N/A	$67,000	$69,000	$71,000
Average Annual Energy Cost Savings	N/A	N/A	$5180	$5750	$6490
Payback Period (yrs)	N/A	N/A	12.9	12.0	10.9
Cost per kwh	N/A	N/A	$0.081	$0.077	$0.072

Figure 16. Economic Evaluation Factors

The Next Step - WindCheck Plus

The WindCheck process as reported here is conducted remotely, and is intended to give the consumer a reasonably-priced first look at how well a small wind system will work for their requirements. The price of this first look WindCheck report is kept low by conducting the wind resource assessment remotely and by assuming average system and installation costs.

The WindCheck analysis may indicate that a small wind system is not an economical solution to providing renewable energy - most often because the winds at a target location are not strong enough or the costs associated with a small wind system (including the turbine, tower, and installation) are higher than expected.

If the first look WindCheck analysis does indicate that a small wind system is a feasible solution, it is strongly recommended that you follow up with smallwind.com's WindCheck Plus analysis. The WindCheck Plus includes a visit to your target location by a certified Wind Site Assessor, who will professionally examine and document the conditions at your target site. Most importantly, the Wind Site Assessor will evaluate the site specific obstructions to the wind and conduct a detailed estimate of installation costs, including factors like electrical system characteristics and the target location's accessibility, both of which can have a dramatic effect on costs.

The WindCheck Plus also allows the client to designate a specific small wind system and tower height for consideration, which allows a more precise calculation of costs and energy generation than the generalized systems used in the WindCheck analysis.

The WindCheck Plus analysis is available at a cost of $575 if there is a certified Wind Site Assessor available within 200 miles. If there is no Wind Site Assessor within that radius, additional travel costs may be required.

You can see an example and order a WindCheck Plus analysis report on the smallwind.com web site. If you have questions about WindCheck, WindCheck Plus, or any other matter, please contact us at support@smallwind.com.