A TOOL TO MARKET CUSTOMER-SITED SMALL WIND SYSTEMS

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ABSTRACT

In order to make the Wind Powering America effort a success, homeowners and landowners interested in purchasing grid-connected small wind energy systems must be provided with assistance and education. The Clean Power Estimator (CPE) program is a valuable tool for these individuals. In support of this educational effort, the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) is integrating the CPE program with site-specific wind resource data. This paper describes how the CPE program works, how end users can determine the cost-effectiveness of wind for a specific location, and how companies can use the program to identify high-value wind locations.

INTRODUCTION

Wind Powering America[1] is a commitment to dramatically increase the use of wind energy in the United States. Homeowners and landowners need help making decisions on the purchase of grid-connected small wind energy systems. This is particularly true for consumers who are making economic decisions regarding producing their own electricity and feeding the excess to the utility grid.

In support of this effort to help consumers, NREL's NWTC is integrating the CPE program with its site-specific wind resource data. The CPE program provides residential and commercial customers with a personalized estimate of the costs and benefits of clean energy systems [1]. This paper describes how the CPE program works, the benefits it provides to the end user, and how NREL is using it.

The CPE program's greatest benefit is its links to databases of rate structures and wind resource data. Users simply select their tariffs and locations, rather than entering all the details of their rate structures and wind resources. This allows the program to more accurately estimate wind turbine production and project economics while maintaining a simple interface. The user is spared from having to gather potentially hard-to-find information.

HOW THE CLEAN POWER ESTIMATOR WORKS

Introduction

CPE is a software program that provides an economic evaluation for customer-owned, clean-energy systems. The program can evaluate a variety of investments, including wind, photovoltaics, solar thermal, energy efficiency, and fuel cells. The program gives a personalized estimate of the costs and benefits of systems for residential and commercial customers. CPE takes into account the characteristics of the customer purchasing the system in order to provide the most relevant analysis.

[1] Information about Wind Powering America can be found at http://www.eren.doe.gov/windpoweringamerica/.

The CPE program can be run in a variety of modes, including stand-alone, client-side Internet, and server-side Internet. In stand-alone mode, the program runs on the user's local computer with no Internet connection. In client-side Internet mode, the user sends a request to the Internet, and the program is sent to the user's computer, where the calculations are performed. In server-side Internet mode, the user makes a request about the cost-effectiveness of a clean energy system and the result, rather than the program, is returned to the user's computer.

As shown in TABLE 1, each mode has its advantages and disadvantages. For example, although stand-alone mode provides a high degree of user privacy and mobility, only one location is accessible, and there is no Web site integration. By contrast, the server-side Internet mode can be tightly integrated into a Web site. This version provides access throughout the United States but scores low in the areas of user privacy, mobility, and dynamic Web site results.

NREL chose to run the program on the client-side Internet. The client-side Internet mode combines some of the best aspects of the stand-alone and server-side Internet modes. Client-side Internet mode provides users with access to data throughout the United States, a high degree of user privacy while the analysis is being performed, and quick analysis results, even for users with slow Internet connections.

TABLE 1. ADVANTAGES (HIGH) AND DISADVANTAGES (LOW) OF CLEAN POWER ESTIMATOR MODES.

	Stand-Alone	**Client-Side Internet**	**Server-Side Internet**
User Privacy	High	High	Low
Data Access	Low	High	High
Program Mobility	High	Low	Low
Access Speed (First Use)	High	Medium	High
Analysis Speed for Users With Dial-Up Connections	High	High	Medium
Web Site Integration	Low	Medium	High
Dynamic Web Site	High	High	Low

Program Initiation

The user begins the CPE program in the client-side Internet mode by connecting to the Internet and selecting a location on a map. This selection determines the average annual wind speed and presents the user with a list of electric rate structures for the area.

The selection of the rate structure initiates the download of analytical routines and precollected data. The data sets include federal, state, and utility economic incentives; average hourly wind profiles; average hourly electric load profiles; and federal and state income tax rates.

Once the program is on the user's computer (it is run in a script language under the user's Internet browser), the user selects the desired wind system and assumptions and performs the analysis. The analysis makes the following calculations: current electricity consumption, wind production, utility bill

savings, emissions reductions, economic incentives, capital and O&M costs, and income tax effects. These calculations are briefly described below.

Current Electricity Consumption

The CPE program asks questions for which people know the answers. Thus, rather than asking consumers to input their annual energy consumption in kilowatt-hours, the program asks them to input their annual utility bill amount in dollars. The program combines the annual utility bill with electric usage data for the customer's location and tariff type to estimate monthly electricity usage.

Wind Production

Wind output is estimated as follows. First, the average annual wind speed is combined with the Weibull-K and the wind turbine's power curve to determine annual wind energy production. Second, hourly production is calculated based on the hourly wind speeds and the wind power curve. Third, hourly production is proportionally adjusted so that the sum of all hours equals the annual production.

Utility Bill Savings

The resulting hourly wind output is subtracted from the current load to obtain the proposed load. The proposed load is then billed at the selected rate structure to obtain the new utility bill. Utility bill savings is the difference between the old and the new utility bills. The program can accommodate a wide range of electric rate schedules, including tiered rates, multiple seasons, time-of-use rates, demand rates, several types of net billing, fixed monthly costs, minimum bills, and sell-back rates.

Emissions Reductions

The total emissions savings is calculated by multiplying the wind output times the emissions reductions per kWh as reported by the U.S. Environmental Protection Agency.

Economic Incentives

Depending on the location and customer type, economic incentives may be available at the federal, state, and utility levels. The incentives are calculated based on the type of equipment purchased, cost, and incentive rules (i.e., how the incentive is calculated). The calculation takes into account interactions among multiple technologies. The taxability of the incentives is then determined, and the tax is calculated based on the marginal tax rate.

Capital and O&M Costs

Wind systems can be paid for in several ways: general loans, home equity loans and refinancing (all of which may have tax implications), non-tax-deductible loans, and cash. The CPE program calculates the payment and tax consequences over the life of the loan.

Income Tax Effects

Depending on the payment method and customer type, a wind system investment can have income tax effects. The tax effects are calculated using the combined federal and state marginal tax rate. This rate is based on the user's taxable income, tax filing status, and the federal and state tax rate schedules. Changes in expenses will change the user's income tax profile. Depending on the type of customer, tax savings may be realized due to loan interest (residential and commercial), equipment depreciation (commercial), and O&M costs (commercial). Tax losses may occur due to reduced expenses (commercial) or including a wind system as part of a home refinance (residential).

Final Result

The CPE program combines the individual components and presents the user with a variety of formats, including simple payback, monthly and annual cost/savings, cash flow, discounted cash flow, cumulative cash flow, net present value, and a variety of technical outputs.

CLEAN POWER ESTIMATOR USES

The CPE program is used by equipment manufacturers, retailers, electric utilities, state government agencies, federal government agencies, and nonprofit groups. These groups have found uses for the program ranging from consumer education to promoting grassroots solar campaigns. Because a variety of uses have been previously documented [2, 3, 4], this section will focus on two ways that NREL is using its version of the program: educating consumers and identifying high-value locations for wind.

Educate Consumers

NREL primarily uses the CPE program to inform consumers about the costs and benefits of wind technologies. By accessing the program over the Internet, users gain a better understanding of what wind can do for them. The program presents the user with the economic benefits (FIGURE 1) and technical performance (FIGURE 2) of wind power.

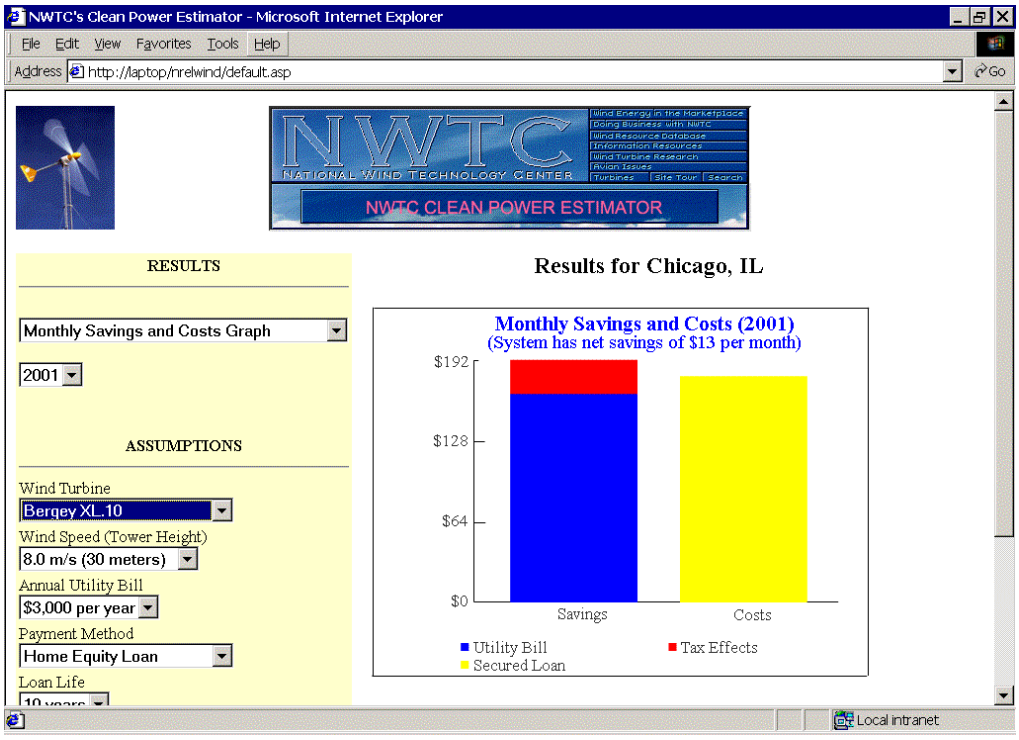


FIGURE 1. SAMPLE ECONOMIC RESULTS (BERGEY XL.10 TURBINE IN CHICAGO, IL).

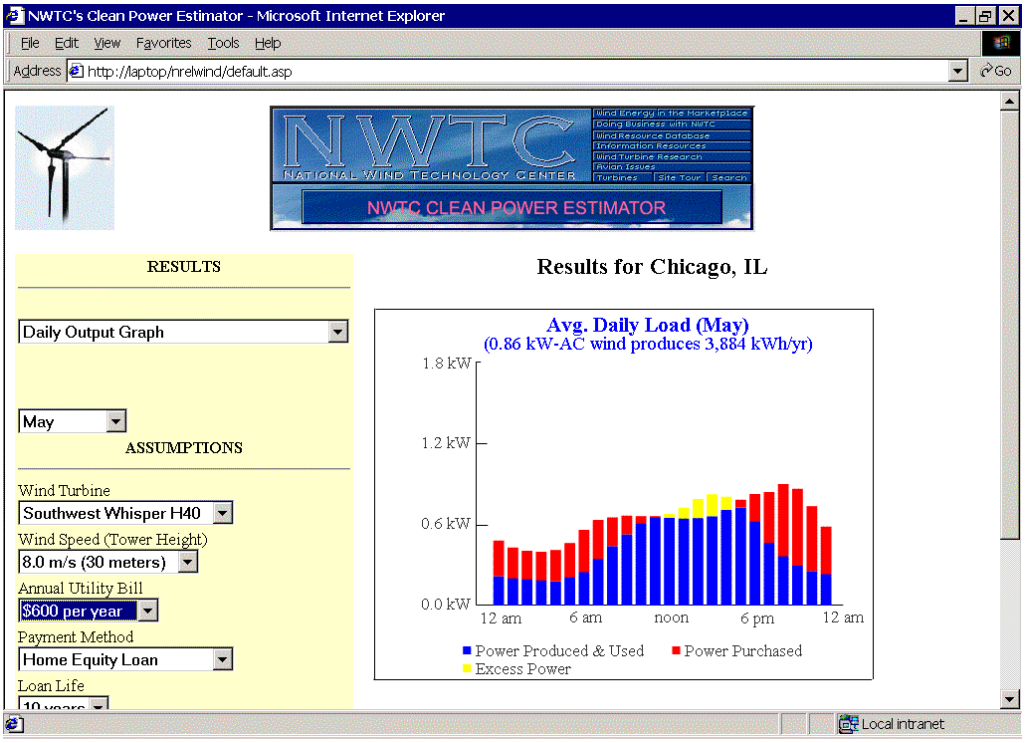


FIGURE 2. SAMPLE TECHNICAL RESULTS (SOUTHWEST WINDPOWER WHISPER H40 TURBINE IN CHICAGO, IL).

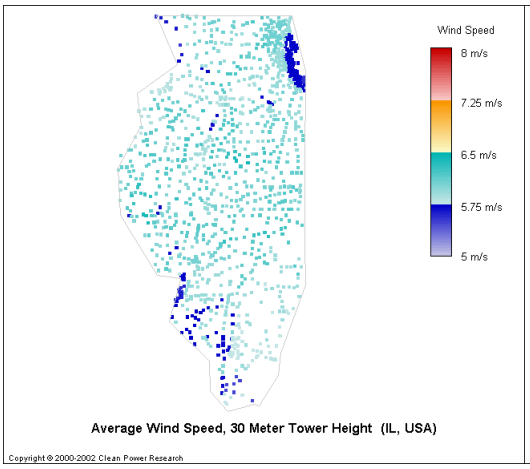
Analyze Market

NREL is also using the program to identify high-value locations for wind. Rather than running the CPE program for a single location and presenting the results, the program is run for all locations, and the result for each location is plotted on a map. As an example, the figures below show the results of a market study for Illinois. FIGURES 3, 4 AND 5 show the assumptions behind the analysis.

Illinois has a quirky grant program that will pay 50% of the cost of a small wind turbine system, but only for systems with a rated capacity of 10 kW or greater. For this reason a Bergey 10 kW wind turbine was selected for this example. Two annual utility bills were selected, $1,400 and $3,000. The former would be a typical bill for a house with electric heat. The latter bill, much larger than the average household bill, would be more typical of a farm or small commercial enterprise. The analysis looks at the Net Present Value (NPV) of the system of the life of the wind turbine.

ASSUMPTIONS

Equipment	Bergey XL 10
Cost before rebate	$35,000
Cost after rebate	$17,500
Annual utility bill	$1,400 or $3,000
Utility bill escalation	2%
Loan life	10 years
System life	20 years
Loan rate	6.5%
Loan type	Loan with tax deductible interest
Income after deductions	$80,000
Tax filing status	Married filing jointly
O&M cost	$50 per year
Tower Height	30 meters



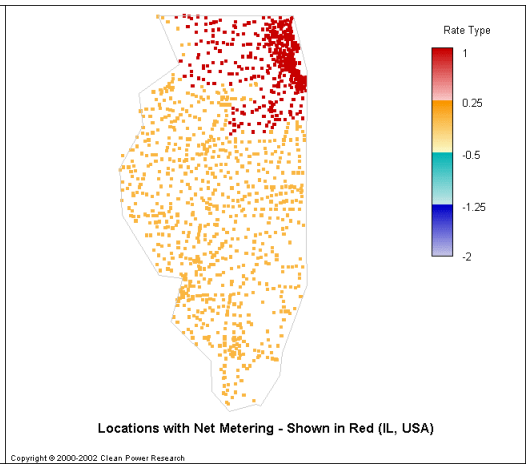


FIGURE 4. AVERAGE ANNUAL WIND SPEED AT 30 METERS.
FIGURE 5. AVAILABILITY OF NET METERING (SHOWN IN RED)

$1,400 Annual Utility Bill $3,000 Annual Utility Bill

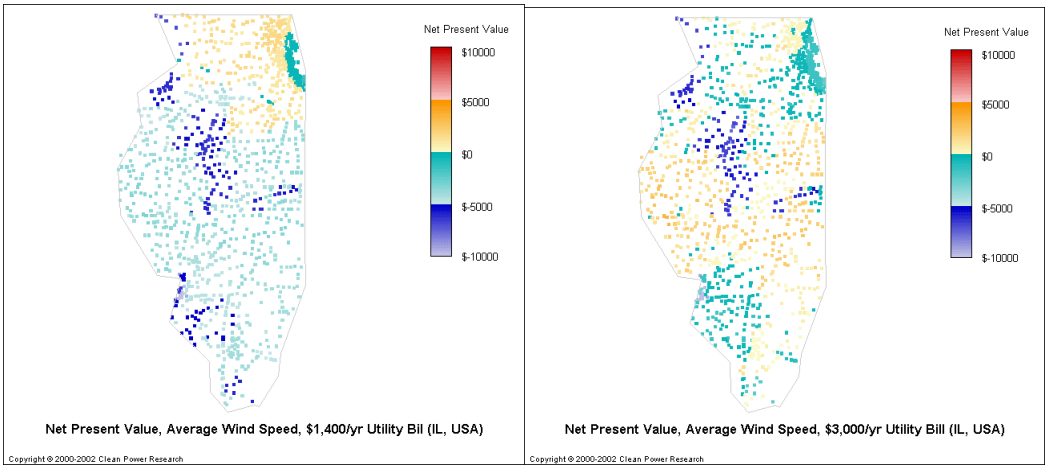


FIGURE 6. COST-EFFECTIVENESS OF WIND IN ILLINOIS FOR RESIDENTIAL CUSTOMERS.

FIGURE 6 shows the results of the market analysis. At first the results for northern Illinois may seem counterintuitive. The system that had a positive NPV with a $1400 utility bill had a negative NPV with the $3,000 annual bill. The reason for this is the decreasing tiered rate structure in northern Illinois. With the greater consumption, the wind turbine is replacing less expensive energy than with the lower consumption and thus the economics are not as favorable.

This same type of study could fairly easily be done for other states.

FUTURE WORK

The large number of defaults in CPE contributes greatly to its ease of use. However, users cannot change many of these defaults. Future work on the CPE program will focus on allowing users to accept the program defaults or enter their own information.

User Input of System Costs

Currently, users cannot change the default cost of the wind turbine system. For the same turbine, system costs can vary widely depending on tower height and whether the turbine is installed by the user or is part of a turnkey system. This program improvement would allow a user to enter a cost reflecting his or her specific circumstances.

User-Specified Height

Currently, for a given location, the wind speed and height are linked together. Future plans for the CPE program include separating these inputs to increase flexibility.

User-Specified Monthly Bill

Currently, users are limited to entering their annual electricity bill. The CPE program uses aggregate customer class information to estimate the monthly consumption. Although for most users this is sufficient, allowing users to input monthly bills increases the value of the tool for those whose usage is not typical or those whose monthly usage cannot easily be estimated from annual information.

Link to High Resolution Wind Resource Database
NREL and others are currently in the process of updating the U.S. wind resource maps. In some areas, the resolution will be as high as 400 meters. Work is under way to link CPE to this data. NREL is exploring two mechanisms for this. One method is to select a location through an online wind resource map. This method is currently available for Illinois. The other method is to input the location's coordinates (latitude and longitude).

CONCLUSIONS

The CPE program is an important component of Wind Powering America's effort to teach the American consumer about the benefits of grid-connected small energy wind systems. The integration of electrical tariff and wind resource data into CPE allows the individual landowner to quickly and easily evaluate the performance and economics of a grid-connected small wind system. This paper described how the CPE program works and demonstrated how the program can be used to determine the cost-effectiveness of wind for a specific location and to identify high-value wind turbine system locations.

ACKNOWLEDGMENTS

[1] T. E. Hoff. Clean Power Estimator. *Proceedings of the 1999 Annual Conference*, American Solar Energy Society, Portland, ME (June 1999).
[2] T. E. Hoff. "Using the Internet to promote PV and other clean technologies", 2001 American Solar Energy Society Annual Conference (April 2001).
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