EMERGING RENEWABLES PROGRAM
SMALL WIND INCENTIVES STUDY

CONSULTANT REPORT

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Abstract

Since the inception of the Energy Commission's Emerging Renewables Program in 1998, California has seen significant fluctuation in the number of small wind systems installed annually, including a steady decline in rebate applications since 2006. Over this period, many factors have influenced the demand for small wind systems, such as: a maturing infrastructure for installers and manufacturers, increasing public exposure to small wind and renewables systems, changing system costs, and varying incentives. In 2009, KEMA analyzed data collected from the Emerging Renewables Program project database and through participant and installer surveys. The analysis included investigation of California's small wind market infrastructure, system performance, trends in size and capacity, annual installation quantities, system costs and payback, and satisfaction. KEMA identified barriers to small wind – from the perspectives of both the owners and the installers. From this analysis, KEMA recommends that the Energy Commission maintains its current incentive level while encouraging customers to take advantage of the recently uncapped federal Investment Tax Credit. In addition, the Energy Commission should revise its certification process to require more comprehensive safety, quality, and performance certification of wind turbines and to simplify certification of inverters. Inverters convert direct current into standard household alternating current power. They are also known as DC to AC converters. To eventually increase small wind performance, the Emerging Renewables Program should develop a production estimation tool and engage in educating and training system installers in proper planning and siting. In conjunction with the tool, the Emerging Renewables Program should work to improve the accuracy and applicability of state wind maps for small wind systems. Lastly, the Emerging Renewables Program should consider increased public outreach and education efforts to promote familiarity and acceptance of small wind systems.

Keywords: Small wind, renewable energy, distributed generation, small wind and photovoltaics comparison, market barriers, rebate analysis, emerging technology, state incentive program, California Energy Commission, Emerging Renewables Program, ERP, Self-Generation Incentive Program, SGIP, program evaluation, wind turbine, turbine certification, permitting, property tax, inverter certification, payback analysis, production estimation tool, wind map, renewable energy economics, consumer education, customer satisfaction

EXECUTIVE SUMMARY

The Emerging Renewables Program (ERP) develops a self-sustaining market for emerging renewable energy technologies for distributed generation applications. To achieve this goal, ERP provides three primary functions—monetary incentives, renewable equipment certification, and consumer education. Since the inception of the Energy Commission's Emerging Renewables Program in 1998, California has seen significant fluctuation in the number of small wind systems installed annually, including a decline in rebate applications since 2006. As a result, the Energy Commission directed its technical support contractor KEMA in 2008 to assess the market infrastructure, economics, and market barriers to the small wind market in California.

As part of the study, the Energy Commission sent 387 surveys to Emerging Renewables Program small wind customers and 31 surveys to small wind retailers, installers (contractors), and manufacturers to gather information on system performance, market trends, and overall satisfaction. By March 2009, 121 customers had returned the surveys, or more than 30 percent of total program participants. Ten industry participants returned the surveys, including eight retailer/contractor and two manufacturers. Together, the retailers, contractors, and manufacturers who participated account for over 60 percent of the small wind products rebated under the ERP, over one-third of the total completed installations, and two-thirds of the installations completed in 2008.

In 2009, KEMA reviewed industry reports, ERP program data, and ERP participant survey data to assess California's existing market infrastructure for small wind systems. Using the customer-reported performance data, KEMA conducted various analyses to assess system performance and cost-effectiveness of small wind systems in ERP. Additionally, with the survey data from March 2009, KEMA evaluated participant satisfaction with the program. Based on these findings, the authors provide recommendations for near- and long-term improvements in this report.

California Wind Market Infrastructure

As of early February 2009, 393 small wind systems have been completed, totaling almost 2.4 megawatts. By analyzing the ERP program data and industry survey data, KEMA finds that:

- **System location**. More than half of these systems (71 percent of all capacity) are installed in the Southern California Edison (SCE) territory. Although Pacific Gas and Electric (PG&E) territory has 40 percent of the total ERP systems, they have only 28 percent of the total capacity. San Diego Gas & Electric (SDG&E), the smallest Investor Owned Utility (IOU) in the ERP program, has only 1 percent of the total capacity installed. Only seven counties have more than ten completed systems. Over one-third of all completed systems are in San Bernardino County; the other counties include Kern, Los Angeles, San Diego, Solano, Butte, and Sonoma.

- **System Size.** The majority of ERP systems are in the 9 kilowatt (kW) range. There is no clear trend in system size over time; however, there is a slight trend toward larger systems in recent years.

- **System Cost.** The data shows two distinct cost averages: those for systems under 3 kW and those for systems 9 kW to 10 kW. The small systems averaged between $7.00 and $7.50 per watt; the larger systems averaged around $5.00 per watt. The uncertainty in turbine price reduced significantly as system capacity increased. Part of the reason for this change is the number of manufacturers providing systems for each size category. The smaller size category has more manufacturers than the large system category, which is dominated by one manufacturer.

- **Manufacturers and Products.** Currently there are 64 wind turbines eligible to be funded by the ERP. These turbines are manufactured by 24 different companies. Despite the diversity in manufacturers and models, only 12 different turbine models have received rebates from the ERP, representing 5 manufacturers. The manufacturers are Bergey Windpower (43 percent), Southwest Windpower (20 percent), REDriven Inc. (2 percent), Wind Turbine Industries (2 percent), and Unitron Energy (less than 1 percent). Although only a fraction of manufacturers and models are active in the ERP, retailers and contractors do not see that as an impediment to their business. Regardless of the number of choices in products, contractors tend to use the same manufacturer models over time.

- **Retailers.** Although the ERP database is not complete, 25 unique retailers are identified. Many of the registered retailers are also licensed contractors. In general, ERP customers are satisfied with their retailers or their equipment purchasing experience with their retailer-contractor.

- **Contractors.** The ERP database does not have installer information for one-sixth of the completed installations; however from the available data, at least 29 percent of the completed systems are installed by Guasti Construction and almost half of the completed systems are installed by seven installers. Many of the small wind contractors also install solar systems. In general, ERP customers are satisfied with their contractors.

- **Customers Satisfaction.** In general, small wind customers are satisfied with their systems. In fact, 68 percent of the customers who responded would purchase their system again. A few mentioned that they would even have a larger system. Eighty percent of respondents would recommend wind generating systems to others.

Market Barriers

In the 2009 Energy Commission survey, manufacturers, retailers, and contractors were asked to rank a list of barriers to selling a small wind turbine or completing a small wind project. The survey responses find that:

- **Siting and Permitting.** Wind retailers and contractors invariably rank siting and permitting as the major barriers in completing wind projects. Many counties have requirements that seem to prohibit installations, including expensive fees, large application packages, long wait times, and codes that are unclear, restrictive, and subject to Not In My Backyard (NIMBY) influence.

- **Permitting Processes Vary.** Permitting time and costs vary widely between counties and, in some cases, within a county. Of the 23 counties where the survey respondents operate, more than half of the counties are considered to have challenging permitting processes, with San Diego County and Imperial County as two of the most challenging. Only a handful of counties received a rating of 1 or 2 for being the easiest to obtain permits; Yuba, Butte, Kern and Glenn Counties are reported to have relative fast and reasonably priced permits.

- **Resource Adequacy**. Contractors and retailers identified wind adequacy as an "average" to "large" barrier. Similarly, ERP customers listed wind adequacy as one of their top five complaints in the 2009 Energy Commission surveys.

- **Noise and Visual Issues.** Installers and manufacturers in general identified visual and noise issues as "somewhat a barrier." In the customer survey, nine customers wrote in complaints about the noise level of their turbines, especially during high winds.

- **Costs**. All the manufacturers, contractors, and retailers who responded to the survey agreed that costs in the past five years have increased between 10 and 28 percent. The increases are mostly due to cost increases in hardware, installation, and permitting.

- **Product Reliability**. Currently there are no requirements in the *ERP Guidebook* to verify performance claims from wind turbine manufacturers. The two main manufacturers in ERP, Bergey Windpower and Southwest, did not think the current certification process ensured quality and performance in small wind systems. The current eligible equipment list does not differentiate wind products that are certified by a third party and those that are rated with self-reported data. The Energy Commission does not have a mechanism to regulate manufacturers that exaggerate their products' performance and therefore this may unintentionally give an unfair advantage to poor performers.

- **Reported System Issues**. Of the 121 customer responses, 17 percent reported electrical problems, 20 percent reported mechanical problems, and 26 percent reported problems associated with low wind. Only 32 percent of respondents experienced no problems with system performance at all, while over two-thirds reported a problem of some kind

with about one-quarter reporting low wind. This issue has generally little to do with the technology or the installation, but rather siting the wind turbine to a specific location.

Performance and Economic Analysis

For small wind systems to emerge as a viable distributed renewable energy technology, small turbine performance must be consistent and sufficient to make a project financially viable with the use of state and federal incentives. The performance of the reported wind systems was analyzed in depth, in part to gain an understanding of whether systems were designed, sited, and installed properly, but also to better understand a system's payback. KEMA's analysis finds that:

- Ninety percent of the respondents reported that their system is still in operation. Of the systems no longer in operation, some of the reasons included: destruction by high winds, removal due to poor winds, removal due to high winds and equipment failure.

- Nearly one half reported that the system performed as expected. The remaining respondents were nearly split on whether their system performed better or worse than expected.

- The capacity factors for ERP's small wind systems vary significantly. The mean capacity factor of 11 percent is in an acceptable range of small wind capacity factors. However, standard deviation of the capacity factors (7 percent absolute) is very large. This reflects the large spread of performance characteristics between those with excellent performance (18 percent or above) and those with dismal performance (4 percent or below). Furthermore, many systems (42 percent) are performing with capacity factors below 8 percent.

- A majority (75 percent) of customer paid for their systems with cash, while 22 percent partially financed the system, and only 2 percent leased the system. These results show that adopters are almost entirely shouldering the entire post-rebate cost of a system, either through cash or loans. This suggests also that the respondents perceive the systems as a capital investment—a purchase with a large upfront cost and a perceived payback.

- Most respondents expected their system to pay for itself in 6–10 years, while more than 30 percent expect a payback of over 10 years. Only 13 percent expect their systems to pay for themselves in 5 years or less. When asked if their payback expectations changed over time, 47 percent of participants did not have a changed expectation of payback, while 35 percent of respondents did report a change in expected payback. The reported changed expectations were skewed toward longer paybacks than the first estimate.

- There is significant discrepancy between expected paybacks and calculated payback. Only 23 of the 121 provided enough accurate information that a payback could be

estimated. The calculated payback range from 6 years to 100 years, with an average payback of 30.3 years and median payback of 21 years.

- With the recent adoption of the federal Investment Tax Credit, KEMA analyzed the payback of small wind systems going forward. There is a clear trend in payback: the larger systems provide a better payback for a given capacity factor than the smaller systems. Between the expected capacity factors of 11 percent to 18 percent, systems smaller than 3 kW yield simple paybacks of 12.7 years to 8.1 years, where systems of 10 kW yield simple paybacks of 6.2 years to 3.9 years.

- The residential photovoltaic systems present similar average payback to small wind systems under 3 kW. The 10 kW wind systems appear to have a better payback for most capacity factors than the residential photovoltaics. Typical residential photovoltaics systems have simple paybacks of 14.7 years and 13.3 years for capacity factors 16 percent and 18 percent.

Recommendations

The goal of the ERP is to accelerate the development of the wind market and to remove as many barriers for the industry as possible. Although it is not within the Energy Commission's power to correct every market barrier, there are some improvements that can be made to the ERP.

1. **Update Performance Certification.** KEMA recommends that the Energy Commission include, as an eligibility requirement, certification to IEC 61400-12-1 "Power performance measurements of electricity producing wind turbines" by a qualified third party. This standard provides a uniform method that will ensure consistency and accuracy in the measurement and analysis of power performance by wind turbine generator systems. One of the main results of applying this standard is generation of a performance curve. The Energy Commission should consult third-party testing facilities before implementing this change and determining a compliance date for the manufacturers.

2. **Adopt New Quality, Durability, and Safety Certification.** In the medium term, a more comprehensive certification protocol should be implemented to account for a products' overall quality (including durability and safety), instead of simply performance. AWEA is developing a standard (AWEA 9.1 – 2009) to have products certified by the Small Wind Certification Council. AWEA 9.1 – 2009 does not include provisions for directly certifying the electrical safety of the generator. Currently, there are two UL standards that cover generator system safety requirements: UL 1004-1 "Rotating Electrical Machines – General Requirements" and UL 1004-4 "Electric Generators." It is recommended that certification of the wind turbine generator to these safety standards also be adopted. Any changes to ERP equipment certification protocols must consider the additional cost burden on equipment manufacturers as it relates to incentive rates that will be provided. In addition, sufficient time must be given to the manufacturers to recertify their products to a new standard.

3. **Maintain Rebate Level and Structure.** KEMA recommends the ERP maintains its small wind rebate at current levels while allowing system owners to take advantage of the newly uncapped investment tax credit (ITC). The ERP should focus its efforts instead on ensuring that durable small wind systems are sited appropriately to ensure consistent and sufficient performance. In coming months, the ERP should reevaluate the penetration of small wind systems resulting from the current ERP rebate level and the implementation of the uncapped ITC.

4. **Develop Production Estimation Tool.** KEMA recommends that the ERP require or suggest the use of a production estimation tool for the planning of small wind systems. Furthermore, the ERP should consider providing seminars to educate contractors on its proper use. The ERP could potentially use pre-existing, publicly available estimation tools or decide to develop one of its own. The use of a production estimation tool, along with improved wind maps, installer siting training, and estimator training, should work to dramatically decrease the uncertainty of estimated energy production numbers. The result should be fewer underproducing systems, greater satisfaction with the program, and overall better payback for the systems.

5. **Increase Inspection and Monitoring Efforts.** To aid future performance monitoring efforts, KEMA recommends that the Energy Commission collects projected system information, such as installers' production estimates, installers' average annual wind estimates and turbine hub height, in the ERP application. In cases where wind performance fall short of customers' expectations, ERP can more easily identify which aspect of the installers' estimate is compromised. This information can help the Energy Commission target installer education and wind data collection in the future.

KEMA also recommends the Energy Commission remove excessive requirements for turbine products that have integrated inverters; validate and improve existing wind resource data; support industry efforts in reforming permitting process; provide installer education and training; and increase consumer education efforts for small wind.

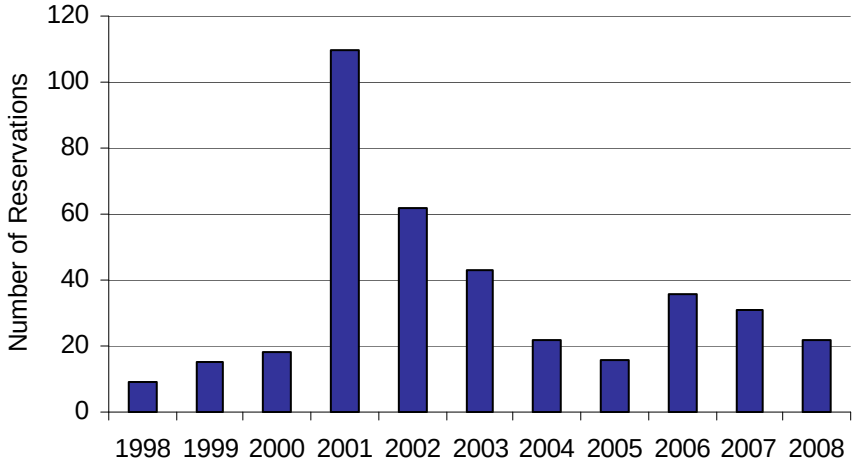
CHAPTER 1: Introduction

The California Energy Commission's Emerging Renewables Program (ERP) was created in 1998 to accelerate the market development of specified emerging renewables technologies for on-site application, including small wind systems. Since then, ERP has become an important driver for California's small wind market. It brings together different market players, including manufacturers, retailers, contractors, and customers through its informational website and rebate application process.

Although California remains one of the largest small wind markets in the United States, the number of small wind incentive applications within California has declined over the past few years. As a result, the Energy Commission contracted KEMA in 2008 to assess the market infrastructure, economics, and market barriers to the small wind market in California.

As shown in Figure 1-1: Number of Projects Reserved by Year, the number of small wind projects applying for rebates under the ERP has decreased since 2001-2003.

Figure 1-1: Number of Projects Reserved by Year



Source: ERP Database

During the same period that small wind applications declined, on-site solar photovoltaic (PV) enjoyed immense market penetration in California. These two emerging technologies provide comparable benefits and have some overlapping consumers but do not land on the same adoption curve. The comparison could be informative. Therefore, it is a recurring theme throughout the report on how small wind fares against solar, how solar overcomes some of the problems small wind is currently facing, and what are the lessons learned from the solar experience.

As part of the study, in late 2008 and early 2009, the Energy Commission sent 387 surveys to Emerging Renewables Program small wind customers, and 31 surveys to small wind retailers,

installers (contractors), and manufacturers to gather information on system performance, market trends, and overall satisfaction. A sample of the surveys is included in Appendix A of this report. By March 2009, 121 customers returned the surveys, representing more than 30 percent of total program participants. Ten industry participants returned the surveys, including eight retailer/contractor and two manufacturers. Together, the industry participants account for over 60 percent of the small wind products rebated under the ERP, over one-third of the total completed installations and two-thirds of the installations completed in 2008.

In 2009, KEMA reviewed industry reports, interviewed stakeholders, and reviewed ERP participant survey data to assess California's existing market infrastructure for small wind systems. Using the customer-reported performance data, KEMA conducted various analyses to assess system performance and cost-effectiveness of small wind systems in ERP. Additionally, with the survey data from March 2009, KEMA evaluated participant satisfaction with the program. Based on these findings, the authors provide recommendations for near- and long-term improvements in this report.

The rest of the report will be organized in this manner:

- Chapter 2: ERP and Its Interaction With Other Small Wind Incentives in California
- Chapter 3: ERP's Role in California's Small Wind Market
- Chapter 4: California Wind Market Infrastructure
- Chapter 5: Market Barriers
- Chapter 6: Performance and Economic Analysis
- Chapter 7: Recommendations

CHAPTER 2: ERP and Its Interaction With Other Small Wind Incentives in California

The Emerging Renewables Program (ERP) and other renewables incentive programs are important drivers for the small wind industry in California. The ERP cannot be reviewed in isolation when assessing the complete market infrastructure for the small wind industry. The following sections describe ERP and how it interacts with other incentive programs available to California customers.

ERP Program Goal and Funding

Senate Bill 90 (Sher, Chapter 905, Statutes of 1997), enacted on October 12, 1997, created the Renewable Resource Trust Fund that placed $54 million under the California Energy Commission's Emerging Renewable Resources Account (ERRA) between 1998 and 2001. The Emerging Renewable Buydown Program (ERBP), funded by the ERRA, operated through most of 2002. It is important to note that there were some uncertainties in the market between 2001 and 2002 when the industry did not know whether the program would continue. In 2003, the Emerging Renewables Program replaced the ERBP. Senate Bill 1038 (Sher, Chapter 515, Statutes of 2002) allocated approximately $118 million to the ERP for the period from 2002 through 2006. Beginning in January 2005, Assembly Bill 135 (Reyes, Chapter 867, Statutes of 2004) authorized the use of an additional $60 million of Renewable Resources Trust Fund dollars to be collected from 2007 through 2011, subject to the repayment requirements of the Public Resources Code. Subsequently, Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006) and Senate Bill 1036 (Perata, Chapter 685, Statutes of 2007) allocated another $282.2 million to the Emerging Renewables Program between 2007 and 2011; this funding is shared with another Energy Commission program—the New Solar Homes Partnership program.[1] These bills direct California's three investor owned utilities to contribute to the ERP fund regularly. The Energy Commission staff believes that the available funds can adequately meet all foreseeable wind rebate applications.

The current ERP focuses on two emerging technologies: small wind turbines and fuel cells using renewable fuels. Small wind in ERP is defined as small electricity-producing, wind-driven generating systems with a rated output of 50 kilowatts or less. Before January 1, 2007, ERP also includes photovoltaics (PV) and solar thermal electric generation; these technologies have since moved to other programs—the California Solar Initiative and the New Solar Homes Partnership.

Since ERP's inception in 1998 through June 2008, 27,884 emerging renewable systems have been installed with support from the program, representing 123.1 megawatts (MW) of distributed renewable electricity capacity, bringing total disbursements to about $402 million. Solar PV has

[1] *California Energy Commission Renewable Energy Program 2008 Annual Report to the Legislature*, October 2008.

dominated ERP in terms of the number of projects installed, total capacity, and total amount in rebate disbursements. Wind and fuel cell projects account for a fraction of ERP; in fact, only a handful of fuel cells projects were completed under the ERP. As of February 2009, 393 small wind systems (that is less than 1.5 percent of all systems installed under the ERP) were installed under the ERP, totaling 2.4 MW[2] (less than 2 percent of total installed capacity in the ERP). Of the $402 million disbursed, about $5.5 million funded small wind.

A primary ERP goal is to accelerate market development of specified emerging renewable generation technologies that are designed to provide part or all of a customer's on-site electrical needs. The ERP provides monetary incentives and equipment certification and works with the Energy Commissions' consumer education program to facilitate the small wind market. Further details on ERP's role in the California market can be found in Chapter 3.

Self Generation Incentive Program (SGIP)

The Self-Generation Incentive Program (SGIP) was originally designed to complement the ERP, providing incentives for distributed generation systems that are not covered by the ERP. SGIP was created in 2001 by the California Public Utilities Commission and is administered by the three California investor-owned utilities. The program has been extended twice and will run through 2011.

The maximum wind system size allowed under the ERP is 50 kilowatts (kW); however, the rebates for such systems are limited to 30 kilowatts or less. The minimum system size for wind turbines rebated under the SGIP is 30 kW. SGIP pays $1.50/watt up to 1 MW and pays a reduced incentive for capacity up to 3 MW. Host customers site can install systems up to 5 MW in project size.

As of December 2008, the program only has one wind project completed and eleven projects under various stages of the application process. These wind projects range from 225 kW to 5 MW, amounting to almost $17.9 million in incentives.

Federal Investment Tax Credits (ITC)

The Federal Energy Improvement and Extension Act of 2008 (H.R. 1424) created tax credits for qualifying small wind customers. Unlike ERP or SGIP, "qualifying small wind turbine" denotes a wind turbine that has a nameplate capacity of not more than 100 kilowatts. Residential and commercial small wind customers are eligible for a 30 percent investment tax credit for systems placed in service by December 2016. The maximum credit for systems placed in service in 2008 was $500 per half kilowatt, not to exceed $4,000. In 2009, The American Recovery and Reinvestment Act (ARRA) removed the $4,000 maximum credit limit for small wind turbines.

[2] All the capacity numbers in this report will be expressed in AC terms (Equipment Rating multiplied by Inverter Efficiency Rating).

Therefore, the wind turbines placed in service after December 31, 2008, have no maximum credit limit. The Federal ITC does not reduce the rebate received under ERP.

California State Tax Credits (Expired)

On October 8, 2001, Governor Gray Davis approved the California Solar or Wind Energy System Credit (SB17x2 Brulte, Chapter 12, Statutes of 2001). The law provided personal and corporate income tax credits for the purchase and installation of wind-driven systems with a peak generating capacity of up to 200 kilowatts. Qualifying systems would need to be certified by the Energy Commission, installed with a five-year warranty, and would be required to be in service in California for at least one year.

The tax credit, for tax years 2001 to 2003, was equal to the lesser of 15 percent of the net purchase cost of a wind-driven system or $4.50 per watt of rated peak generating capacity. After January 1, 2004 and before January 1, 2006, the tax credit was reduced to 7.5 percent of the net installed system cost. The tax credit expired on January 1, 2006, and has not been renewed.

Like the federal ITC, the California State Tax Credit did not reduce the ERP rebate. Instead, the state tax credit was calculated after deducting the value of any municipal, state, or federal sponsored financial incentives, including ERP rebate.

American Recovery and Reinvestment Act of 2009

Aside from removing the wind ITC cost caps, the American Recovery and Reinvestment Act (ARRA), signed on February 17, 2009, provides a host of other benefits to the small wind industry[3], including the following:

- Advanced Energy Manufacturing Credits (Section 1302) provide $2 billion worth of energy-related manufacturing investment credits at a 30 percent rate. These credits apply to projects creating or retooling manufacturing facilities to make components used to generate renewable energy.

- Extension of bonus depreciation for businesses (Sec. 1201) extends bonus depreciation for capital expenditures incurred in 2009. This allows businesses to recover the costs of capital expenditures made in 2009 faster than the ordinary depreciation schedule would allow by permitting them to immediately write off 50 percent of the cost of depreciable property (for example, equipment, tractors, wind turbines, solar panels, and computers) acquired in 2009 for use in the United States.

[3] AWEA, *Summary of Final Provisions in H.R. 1, the American Recovery and Reinvestment Act (ARRA) of 2009, of Interest to Small Wind Turbine Producers and Consumers,* downloaded from www.awea.org.

- Research and Development (Division A, Title IV) provides $1.25 billion in undesignated funding through the Department of Energy's Energy Efficiency and Renewable Energy program for applied research, development, demonstration, and deployment activities.

On the demand side, provisions such as the bonus depreciation are designed to make renewable energy, including small wind, more attractive to customers. On the supply side, the manufacturing credit can potentially increase the number of market players and allow existing players to expanding their production capacity. The research and development grants can potentially improve the quality and selection of small wind products in the market.

Other Incentives

Incentives received from sources other than the ERP that lower the cost of a generating system may affect the ERP rebate amount. No less than five percent of incentives received or expected to be received from other sources must be subtracted from the ERP rebate amounts. The percent reduction would be increased as necessary to ensure the sum of all incentives received or expected to be received from all sources, including the ERP, does not exceed the total cost of the system.

CHAPTER 3: ERP's Role in California's Small Wind Market

The primary goal of the ERP is to develop a self-sustaining market for "emerging" renewable energy technologies for distributed generation applications. To achieve this goal, ERP provides three primary functions—monetary incentives, renewable equipment certification, and consumer education. This section describes the three primary functions of ERP and how satisfied participants are with the program.

Rebate

ERP offers rebates to reduce the initial costs of emerging renewable systems to customers, which, in turn, stimulates market demand for such technologies. Increased sales of these generating equipment are expected to encourage manufacturers, sellers, and contractors to expand their operations and reduce their costs per unit. To ensure that the costs of these systems decrease over time, the rebate levels for all technology types are periodically reduced over time.

The current rebate for a small wind system is $2.50 per watt for the first 7.5 kW, and $1.50 per watt for increments between 7.5 kW and 30 kW. In addition, qualified affordable housing[4] projects receive a rebate 25 percent higher than the standard rebate, up to 75 percent of the system cost.

Equipment Certification

The Energy Commission maintains a list of equipment that is eligible for receiving rebates under ERP. The equipment list includes wind turbines, performance meters, and inverters. The list is updated monthly to reflect new equipment and changes to existing equipment. *The Emerging Renewables Program Guidebook*, Eighth Edition, CEC-300-2006-001-ED8F, December 2006, gives the following criteria for wind turbine eligibility:

There are two options to achieve ERP eligibility for small wind systems:

1. Small wind turbines must be certified as meeting the requirements of a small wind turbine-specific safety and/or performance standard adopted by a national or international standards setting body, including, but not limited to IEC (International Electrical Code) 61400-2. The Energy Commission will monitor, review, and may participate in the Interstate Renewable Energy Council's efforts to create a national certification program.

[4] The criteria for qualifying an affordable housing project for the higher rebate can be found in Section VIII ("Special Funding") of the current *Emerging Renewables Program Guidebook* published on the Energy Commission website.

2. Manufacturers of small wind systems must provide monthly data of average energy produced (kWh) and average wind speed for one consecutive year for each model of system they wish to be considered eligible for this program to demonstrate reliable operation of that model of equipment at a site with average annual wind speeds of at least 12 mph."

There are shortcomings with these certification methods that will be discussed in Chapter 5. Product Reliability and Performance; turbine certification and inverter certification are discussed in Chapter 7.

Consumer Education

The Energy Commission maintains a website— http://www.consumerenergycenter.org/—with useful information for potential renewable energy systems purchasers. The website includes links to ERP program information, eligible equipment, and links to external websites with relevant information.

In addition, the Energy Commission published a set of useful guidelines for potential renewable energy consumers. These include:

- *FAQs of Net Metering*, August 2005
- *Frequently Asked Questions For Buying a Small Wind Electric System*, August 2005
- *Clean Power Estimator*, August 2005
- *Permitting Small Wind Turbines: A Handbook Learning from the California Experience*, September 2003
- *Buying a Small Wind Electric System*, February 2002.

ERP has provided solar installers and building inspectors training in the past but have not provided small wind installers training or workshops to date.

Participant Satisfaction

Since the primary functions of ERP are to provide monetary incentives, renewable equipment certification, and consumer education, this section addresses consumer satisfaction in these three areas.

Monetary Incentives

The disbursement of monetary incentives is preceded by an application process, known as the rebate reservation request. The reservation request guarantees funding from the ERP before a customer commits to the project. According to the ERP database, half of the rebate reservation requests were processed within 24 days of receipt. However, the average processing time is 46 days. The delays can be attributed to the availability of ERP staff as well as insufficient or unclear information provided by the applicants. In the 2009 Energy Commission survey,

contractors were asked to score the reservation process from very difficult (5) to very easy (1); the average and median scores were both 3. No contractor said the application process was "very difficult."

In a separate survey, wind customers are asked how satisfied they are with the rebate application process, with 5 being very satisfied and 1 being not at all satisfied. Wind contractors usually handle rebate paperwork for their customers. Therefore, it is not surprising that customers gave an average score of 4.2 out of 5 (Table 3-1). The satisfaction could be attributed to the satisfaction of how their installers handled the rebate application or the rebate application itself.

Table 3-1: Customer Rebate Application Process Satisfaction

Rebate application process satisfaction (all customers)			
Average Score	**4.2**	**N=116**[5]	100%
Very Satisfied	5	60	52%
Somewhat Satisfied	4	34	29%
Neutral	3	11	9%
Somewhat Dissatisfied	2	7	6%
Not at all Satisfied	1	4	3%

Source: ERP Small Wind Customers Survey

Among the survey participants, there were 21 customers who installed the wind system themselves and most likely handled their own rebate application. When this subset is isolated, the average score on rebate application process satisfaction is still 4.2 out of 5 (Table 3-2).

[5] Not all the customers responded to this question. Some responded with "Not Applicable".

Table 3-2: Customer-Installer Application Process Satisfaction

Rebate application process satisfaction (owner-installer)			
Average Score	**4.2**	**N=21**	100%
Very Satisfied	5	9	43%
Somewhat Satisfied	4	9	43%
Neutral	3	2	10%
Somewhat Dissatisfied	2	1	5%
Not at all Satisfied	1	0	0%

Source: ERP Small Wind Customers Survey

The satisfaction and adequacy of the actual monetary incentive will be discussed in Chapter 6, Economic Analysis.

Equipment Certification

With the advent of an increasing number and types of wind turbine products on the market, there have been increasing complaints and questions concerning the current wind turbine eligibility protocols in place for the ERP. Issues regarding product performance and safety will be elaborated more in Chapter 5 Product Reliability and Performance, and Chapter 7 Turbine Certification and Inverter Certification.

Consumer Education

Manufacturers and contractors generally find that ERP program assistance (website, documents, and program staff) is helpful, and in some cases essential to their sales. Half of them think that ERP program assistance is "excellent" or "very good." Of the 10 respondents, four think that ERP program assistance is "average," and only one thinks it is "below average."

Customers who responded to a similar question found the level of information provided by the ERP "somewhat satisfactory," rating it 3.8 out of 5, with 5 being "very satisfied" (Table 3-3).

Table 3-3: Customer Satisfaction With the Level of Consumer Information Provided by ERP

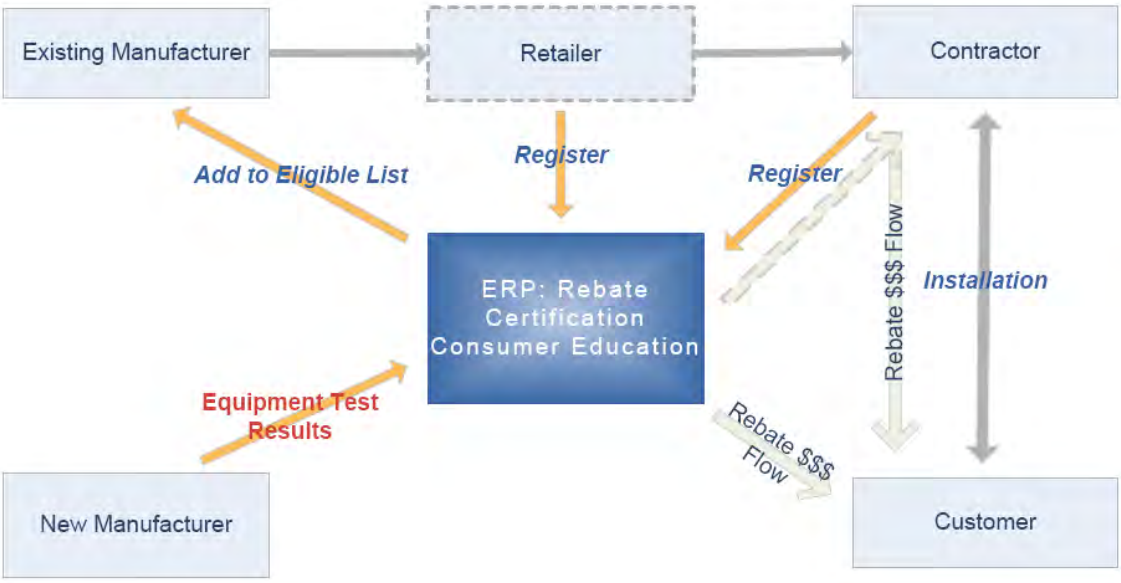
Satisfaction of the Consumer Information			
Average Score	**3.8**	**N=110**	100%
Very Satisfied	38	5	35%
Somewhat Satisfied	29	4	26%
Neutral	29	3	26%
Somewhat Dissatisfied	7	2	6%
Not at all Satisfied	7	1	6%

Source: ERP Small Wind Customers Survey

CHAPTER 4: California Small Wind Market Infrastructure

ERP brings together different players in California's small wind market, including manufacturers, contractors, and customers. All manufacturers must list their equipment with ERP by providing necessary certifications and test data to the Energy Commission. Retailers and contractors must register with ERP annually to be allowed to sell to ERP customers. ERP small wind customers could find eligible equipment and retailers/contractors through ERP's website. Most importantly, customers could receive rebate directly from the Energy Commission or through their contractor. The following chart shows how various players in California's small wind market interact with ERP and each other.

Figure 4-1: Flow Chart of California's Small Wind Market



Source: Figure done by authors

This section provides an overview of installed and rebated systems (completed systems[6]) under ERP. As of early February 2009, 393 small wind systems have been completed, totaling almost 2.4 MW. The map below shows the geographic distribution of all the ERP small wind systems in California. The smallest dot represents a single wind system installed at the ZIP Code. The size of the dot increases proportionally to the number of systems installed at the location.

[6] In this report, "complete systems" mean systems that are installed and rebated by the ERP. The Energy Commission, however, does not track the operational performance of these systems, so it is possible that some of the completed systems no longer work. The ERP periodically verifies a sample of the completed systems against their rebate applications and for their installation quality. Aside from the periodic verification, the Energy Commission has no other means to ensure the rebated systems work.

Figure 4-2: ERP Small Wind Systems Distribution[7]

Source: ERP Database

Over half of these systems (accounting for 71 percent of all capacity) are installed under the Southern California Edison (SCE) territory. Pacific Gas and Electric (PG&E) territory has 40 percent of the total ERP systems but only 28 percent of the total capacity. San Diego Gas & Electric (SDG&E), the smallest IOU in the ERP program, has only 1 percent of the total capacity installed.

[7] Two ZIP Codes are excluded from this map because they are not available in the mapping software Arcview. These ZIP Codes are 92344 (Oak Hills/Hesperia) with 15 sites and 94517 (Clayton) with 1 site.

Table 4-4: ERP Small Wind Systems by Service Territory

	Number of Systems		Total capacity (kW)	
PG&E	156	40%	676	28%
SCE	221	56%	1,706	71%
SDG&E	16	4%	35	1%
Total	**393**	**100%**	**2,417**	**100%**

Source: ERP Database

Only seven counties have over ten completed systems. Over one-third of all completed systems are in San Bernardino County: the other counties include Kern, Los Angeles, San Diego, Solano, Butte, and Sonoma.

Table 4-5: Counties With Over 10 Completed Systems

County	Number of Systems
San Bernardino	136
Kern	39
Los Angeles	25
San Diego	16
Solano	14
Butte	13
Sonoma	10

Source: ERP Database

Among the 393 systems in the ERP, the size and cost of systems vary. Although ERP provides rebates for wind systems up to 30 kW, the largest system completed under the ERP is 20 kW. In fact, only a handful of systems are above 10 kW. One explanation to account for this might be that ERP changed its incentive structure in 2003 so that capacity above 7.5 kW receives a reduced rebate. Therefore, there is a reduced incentive to size the system much larger than 7.5 kW. In addition, unlike PV, which is modular and system size can be increased in small increments, small wind system size is limited to the turbine sizes that are available. Since there are a limited number of small wind products in the market, particularly for products above 10 kW, customers might be less inclined to install larger systems.

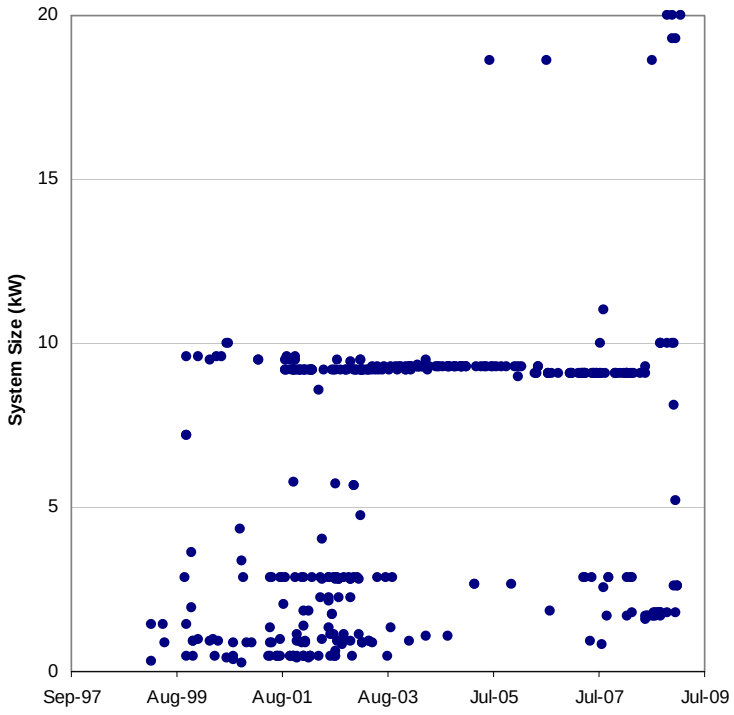
Table 4-6: ERP Program Statistics

Total Completed Systems	393 systems
Total Installed Capacity	2,417 kW
Maximum Size	20 kW
Average Size	6 kW
Median Size	9 kW
0-5 kW	168 systems
5-10 kW	216 systems
>10 kW	9 systems
Average System Cost ($/kW)	$ 6.14
Median System Cost ($/kW)	$ 5.39

Source: ERP Database, calculations done by authors

The majority of ERP systems are in the 9 kW range. There is no clear trend in system size over time; however, there is a slight trend toward larger systems in recent years.

Figure 4-3: System Size



Source: ERP Database

System costs in the ERP vary – 80 percent of the systems in the ERP range from $3 to $8 per installed watt. The average system cost in the entire program is approximately $6.14 per watt, and the median cost is $5.39 per watt. The installed costs for systems completed under the ERP in the past 10 years have shown a slight trend of increase.

Figure 4-4: System Cost 1998-2008

Source: ERP Database

The relationship between system size and system cost is shown in Table 4-4. The data collected are from all respondents from 1999 to 2008. The data show two distinct cost averages: those for systems under 3 kW and those for systems 9 kW to 10 kW. The small systems averaged between $7.00 and $7.50 per watt; the larger systems averaged around $5.00 per watt. The uncertainty in turbine price reduced significantly as system capacity increased. Part of the reason for this change is the number of manufacturers providing systems for each size category. The smaller size category has more manufacturers than the large system category, which is dominated by one manufacturer. These price trends, while representing survey responses, do not reflect price trends over the period, in which turbine prices have generally increased.

Table 4-7: System Cost Trends by Size

System Capacity Range [kW]	Number of Respondents	Average Cost [$/W]	Standard Deviation [$/W]
0 kW - 1 kW	14	$ 7.50	$ 5.10
1 kW - 2 kW	14	$ 7.04	$ 2.09
2 kW - 3 kW	14	$ 7.50	$ 2.48
3 kW - 9 kW	2	$ 7.71	$ 3.21
9 kW - 10 kW	73	$ 5.02	$ 1.00
10 kW +	2	$ 5.02	$ 3.55
All	119	$ 5.89	$ 2.48

Source: ERP Database, calculations done by authors

Further details in system costs by categories and trends will be discussed in the next chapter.

ERP Equipment Manufacturers and Products

In a 2008 market study, the American Wind Energy Association (AWEA) identified at least 49 companies in the United States that manufacture or plan to manufacture small wind turbines. About one-half of the 49 companies began sales in 2008. The U.S. manufacturers have 100 different models in various stages of development. There are at least 84 non-U.S. small wind manufacturers worldwide. They account for approximately 40 percent of the U.S. system sales. A list of small wind turbine equipment providers can be found in the AWEA small wind website: http://www.awea.org/smallwind/smsyslst.html.

Although there are many small wind products in the U.S. market, not all of them are eligible to be on the ERP equipment list. While small turbines are generally defined as having a capacity of up to 100 kW, the ERP defines small wind as systems with a maximum capacity of 50 kW. Moreover, the ERP provides rebates only for wind systems that are of on-grid applications, so turbines that are designed for other uses, such as off-grid or marine uses, are excluded from the rebate program.

Currently there are 64 wind turbines eligible to be rebated by the ERP. These turbines are manufactured by 24 different companies[8]. Despite the diversity in manufacturers and models, only 12 different turbine models are known to have received rebates from the ERP, representing 5 manufacturers. The manufacturers are Bergey Windpower, Southwest Windpower, REDriven Inc., Wind Turbine Industries, and Unitron Energy.

[8] The list of eligible wind turbines can be found here: http://www.consumerenergycenter.org/cgi-bin/eligible_smallwind.cgi

Table 4-8: Small Wind Manufacturers Active in ERP

Manufacturers	Location	Products[9]
Bergey Windpower	Norman, Oklahoma	BWC 1500, BWC EXCEL, BWC XL.1
Southwest Windpower	Flagstaff, Arizona	Skystream 3.7, AIR, Whisper 100, 200 & 500
REDriven, Inc.[10]	Iroquois Ontario Canada	FD6.4-5000; FD3.6-2000; FD10.0-20K; FD8.0-10K; FD3.0-1000
Wind Turbine Industries	Prior Lake, Minnesota	Jacobs 31-20; 27-17.5; 26-15; 23-12.5; 23-10
Unitron Energy Pvt, Ltd.	Pune, India	UE 6; UE 15; UE 33; UE-42

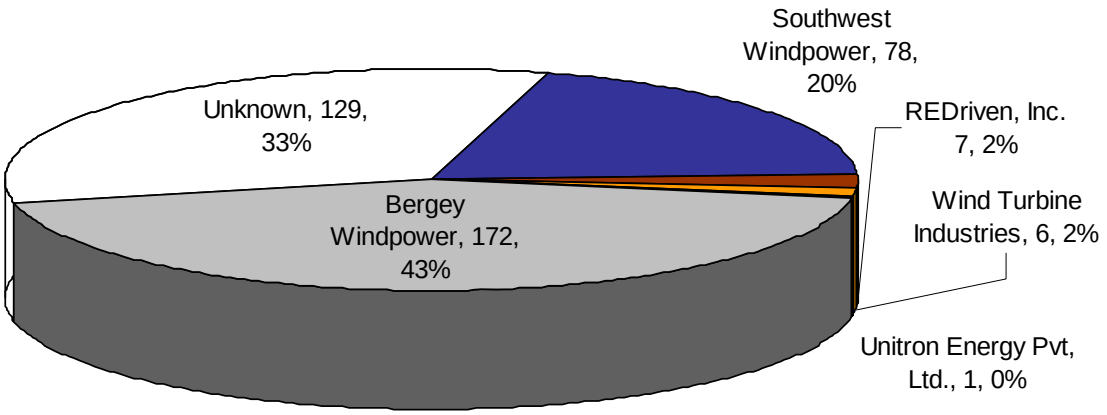
Source: ERP Database

The ERP database includes manufacturer information for two-thirds of the completed systems. From the information that is available, Bergey's wind systems represent at least 43 percent of all completed systems in the ERP. Southwest Windpower represents at least 20 percent of the completed systems, and the rest of the manufacturers make up of the remaining 4 percent of the completed systems.

[9] Not all the listed products are eligible under the ERP.

[10] Renamed from Yangzhou Shenzhou of Jiangdu City, Jiangsu Province, China.

Figure 4-5: Distribution of Wind Turbine Manufacturers



Source: ERP Database

The most common turbine is the Bergey Windpower BWC EXCEL 10 kW turbine (162 systems, about 41 percent of total systems). The next popular models are Southwest Windpower Skystream 3.7 (25 systems, 6 percent), AIR403 (22 systems, 6 percent), and Whisper 500 (21 systems, 5 percent).

Although only a fraction of manufacturers and models are active in the ERP, retailers and contractors do not see that as an impediment to their business. In the 2009 Energy Commission survey, when contractors and retailers were asked if access to wind turbines was a barrier, half responded that it was not and, on average, they reported that was only a minor barrier. Regardless of the number of choices in products, contractors tend to use the same manufacturer models over time. This may be because contractors are more comfortable with installing systems that are known to be reliable. As discussed in later chapters, the ERP only has a few dominant contractors, and these contractors' preferred models are naturally the majority of models rebated under the ERP.

Table 4-9 ERP Systems Manufacturer and Model

Manufacturer	Model	Number of systems	% of Total Systems
Bergey Windpower		**172**	**44%**
	BWC EXCEL	162	41%
	BWC XL.1	8	2%
	Unknown	2	1%
Southwest Windpower		**78**	**20%**
	AIR403	22	6%
	Skystream 3.7	25	6%
	Whisper 500	21	5%
	Whisper 100	5	1%
	Whisper 200	4	1%
	Unknown	1	0%
REDriven, Inc.		**7**	**2%**
	FD10.0-20K	5	1%
	FD8.0-10K	2	1%
Wind Turbine Industries		**6**	**2%**
	23-10	4	1%
	31-20	2	1%
Unitron Energy Pvt, Ltd.		**1**	**0%**
	UE 42	1	0%
Unknown		**129**	**33%**
Total		**393**	**100%**

Source: ERP Database

In Chapter 5, market barriers will explain further why contractors tend to use the same models over time and have not been open to experimenting with new products.

Future Equipment Manufacturers and Products

More than 25 countries are home to small-turbine manufacturers, led by the United States, the United Kingdom, Canada, and Germany. Government incentives, environmental values, and high cost of electricity rates continue to fuel growth in the global small wind market. New technologies continue to emerge to enhance hardware performance, software functionality, durability, safety, and aesthetics. According to the 2008 AWEA Global Market Study, more than 300 different models, in various stages of development, exist worldwide. The Energy Commission, through its technical contractor KEMA, continues to receive small wind turbines certification requests at a pace of about a dozen new turbines per month. About half of these requests are approved each month while the rest are rejected for lack of certification or adequate field data. Requests from foreign manufacturers, especially from Asia, have increased in recent months.

Urban wind technology is a sub-sector of the small wind industry that is notable because of its increased interest in recent years. Urban wind technologies have been modified from traditional ground-mounted installations in open spaces to be used in more densely-built urban areas. Most urban wind technologies are relatively new and limited systems have been installed throughout the United States. Currently, none of these products are certified under the ERP, but manufacturers have expressed interest in obtaining certification.

A synopsis of selected urban wind technology companies are described below:

- AeroVironment, Monrovia, CA. AeroVironment is the most established company selling building-integrated turbines. Its turbines are designed for quick and easy installation onto concrete tilt-up buildings with little or no structural impact.
- Marquiss Wind Power, Folsom, CA. Marquiss's ducted wind turbines are designed to optimize performance on flat rooftops, such as commercial and industrial rooftops.
- Windterra, Calgary, Alberta, Canada. Windterra engineers, designs and manufactures roof-mounted small-wind turbine systems for residential applications. Its Vertical Axis Wind Turbine (VAWT) is designed to operate in micro-winds as low as 4 meters/second (14.5 km/h, 9 mph) and can withstand winds as strong as 40 m/s (145 km/h, 90 mph).
- Aerowind, Zhuhai, Guangdong, China. Aerowind specializes in designing and manufacturing small wind turbines, both vertical-axis wind turbine and horizontal-axis wind turbine.
- Blue Green Pacific (BGP), San Francisco, CA. BGP wind turbines are small wind generators that can be installed in backyards or mounted on roofs in high-density urban environments.
- Deerpath Energy, Marblehead, MA. Deerpath systems strategically use existing streetlight and parking lot lighting infrastructure to site micro-wind turbines that can feed the local grid with renewable power.

Although new manufacturers emerge constantly with new products, their success in the market depends on their ability to gain customer confidence.

Retailer

Companies that sell wind equipment under the ERP (retailers) must register their business information with the Energy Commission annually. Although the ERP database is not complete, 25 unique retailers are identified. While most of the registered retailers are also contractors, some retailers such as Energy Options and Sierra Solar Systems, do not install systems. Many retailers in the ERP also double as solar equipment retailers and contractors.

In general, ERP customers are satisfied with their retailers or their equipment purchasing experience with their retailer-contractor[11]. In the 2009 survey, customers were asked how satisfied they were with their vendor/retailer, with 5 being "very satisfied" and 1 being "not at all satisfied." The average score for retailer satisfaction was 3.9, and the median score was 5.0; 81 percent of the customers who responded to this question gave a score of 3 or above.

Table 4-10: Retailer (Vendor) Satisfaction

Retailer (Vendor) Satisfaction			
Average Score	**3.9**	**N=115**	100%
Very Satisfied	5	62	54%
Somewhat Satisfied	4	18	16%
Neutral	3	13	11%
Somewhat Dissatisfied	2	9	8%
Not at all Satisfied	1	13	11%

Source: ERP Small Wind Customers Survey

Manufacturers surveyed thought there should be more retailers in California. Bergey Windpower commented that California has lost 75 percent of its retailers, because of discouraging permitting processes and decrease in demand. Southwest Windpower concurred and commented that California needs at least one retailer for every 100 square miles. On the other hand, most retailers and contractors think there are enough retailers in California. As Prevailing Wind Power claimed, "Most [retailer] are not reliable. Consumers will be better served by a small handful of well-trained and reliable companies. Many give up after trying to get a permit."

[11] A separate question is being asked about their satisfaction with their contractor.

Contractor

ERP installers, except for owner-installers, must possess an A, B, or C contractor license with California Contractor State License Board to participate in the program. Customers are also allowed to self-install if they forfeit 15 percent of their rebate. In this report, "contractors" and "installers" are used interchangeably; however, in some cases, "contractors" specifically refer to persons who sell their installation services to customers, while "installers" refer to persons who install renewable energy systems, including those who install systems at their own homes or businesses.

There are at least 47 owner-installed systems[12] in the ERP (12 percent of total completed ERP systems). The ERP database does not have installer information for one-sixth of the completed installations; however from the available data, at least 29 percent of the completed systems are installed by Guasti Construction and almost half of the completed systems are installed by seven installers. For the remaining 150 or so systems with known installers, there are at least 120 different installers. These are either installed by owners or contractors who have completed less than five systems in the ERP.

Table 4-11 lists the major installers in the ERP.

Table 4-11: Installers in the ERP

	All years	
Owner-installed Systems	47	12%
Guasti Construction, Inc.	115	29%
Specialized Turbine Services	25	6%
Renewable Technologies, Inc.	14	4%
G.S.E. Solar Systems	10	3%
Prevailing Wind Power	8	2%
Energy Plus	6	2%
Six Rivers Solar, Inc	6	2%
Contractor with less than 5 systems	94	24%
No installer information	68	17%
Total number of systems	**393**	**100%**

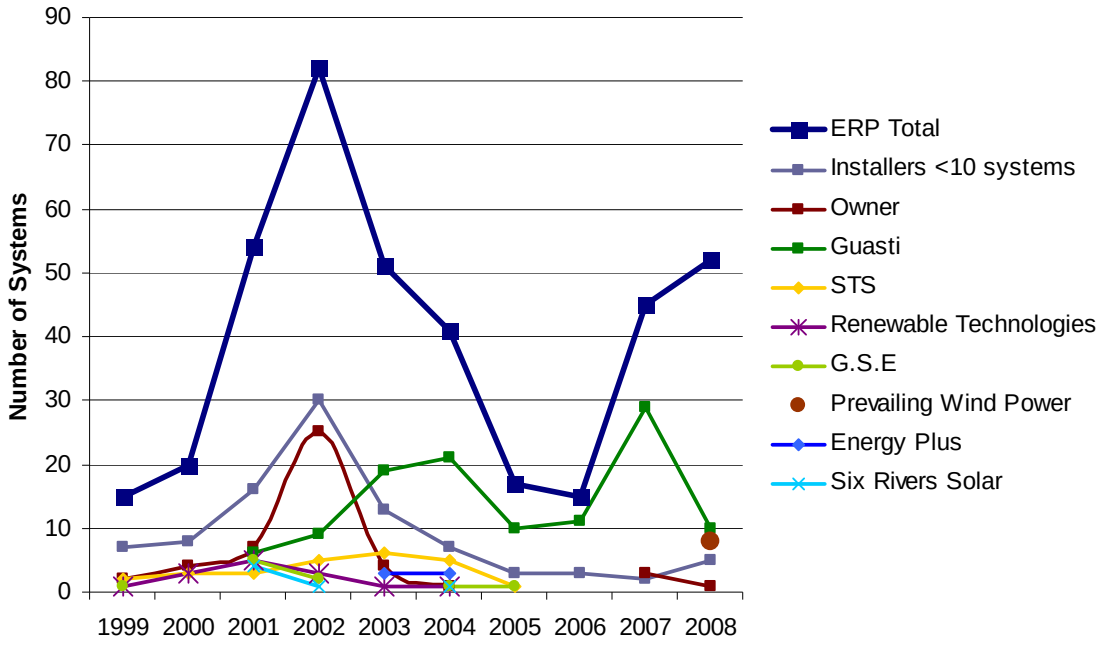
Source: ERP Database

[12] Owner-installer could be licensed contractors as well.

As shown in Figure 4-6, the level of activity by major contractors shifted over the years. There was a boom in small single-installation companies and self-installations in 2001 and 2002; however, the number of these installers decreased rapidly after 2002 and did not shown signs of rebound in subsequent years. At the same time, during the 2001-2002 boom, Guasti Construction was able to build up its market share and has since maintained it to follow the boom and bust of the ERP reservations cycle. Medium-sized companies, such as Specialized Turbine Services, Renewable Technologies, and G.S.E Solar Systems, were major market players in the first five years of the ERP program (1999-2003); however, they have completed few or no systems since then. Conversely, companies including Prevailing Wind have started to gain ground since last year, installing eight systems (15 percent of the installed systems in ERP).

As mentioned previously, Bergey Windpower believed that California has lost 75 percent of its contractors because of discouraging permitting processes and a decrease in demand. The following graph shows the activity of major installers in ERP over the last 10 years.

Figure 4-6: Completed Systems by Major Installers[13]



Source: ERP Database

Many of the small wind contractors also install solar systems. In fact, it is assumed that most contractors who have only completed few wind systems are primarily solar contractors. Most of the wind contractors work locally; as this will be elaborated in later sections, challenging local permitting rules and regulations may prevent contractors from venturing beyond those permitting processes with which they are already familiar.

[13] In this chart, "ERP Total" includes systems that have unknown installers; therefore the sum of the installer data lines do not exactly add up to the "ERP Total".

In general, customers are satisfied with their contractors. In the 2009 survey, customers were asked how satisfied they were with their installer/contractor, with 5 being "very satisfied" and 1 being "not at all satisfied." The average score was 4.0. Eighty-one percent of the respondents gave a score of 3 or above.

Table 4-12: Installer Satisfaction

Installer satisfaction			
Average Score	**4.0**	**N=107**	100%
Very Satisfied	5	66	62%
Somewhat Satisfied	4	10	9%
Neutral	3	11	10%
Somewhat Dissatisfied	2	8	7%
Not at all Satisfied	1	12	11%

Source: ERP Small Wind Customers Survey

There is not a strong correlation between customer satisfaction and the number of systems the installer has completed. However, the ERP data shows that the companies with low survey satisfaction ratings are no longer in business or active in the installation market[14].

Table 4-13: Satisfaction Ratings for the Top 7 ERP Installers

	# Completed	# Responses	Score
Guasti Construction, Inc.	115	39	4.3
Specialized Turbine Services	25	6	1.3
Renewable Technologies, Inc.	14	2	4.5
G.S.E. Solar Systems	10	2	5.0
Prevailing Wind Power	8	4	5.0
Energy Plus	6	3	2.7
Six Rivers Solar, Inc	6	1	3.0

Source: ERP Small Wind Customers Survey

Chapter 5 Market Barriers will further discuss why customers are not always satisfied with their contractors.

[14] This point will be further elaborated in Chapter 5: Market Barriers. Although the data seems to suggest that low satisfaction from customer might have caused the decline of an installer, some customers are dissatisfied with their installers because they went out of business, and therefore their five year installer warranty was no longer valid.

Customers

The ERP targets residential customers and small commercial customers; however, it does not exclude large commercial customers, industrial customers, agriculture customers, or governmental agencies from applying for ERP rebates. The Energy Commission does not collect information on small wind customer types, so there is no way to profile small wind customers in California. However, one characteristic emerged from the customer survey responses is that many wind customers are also solar customers or are thinking of being solar customers.

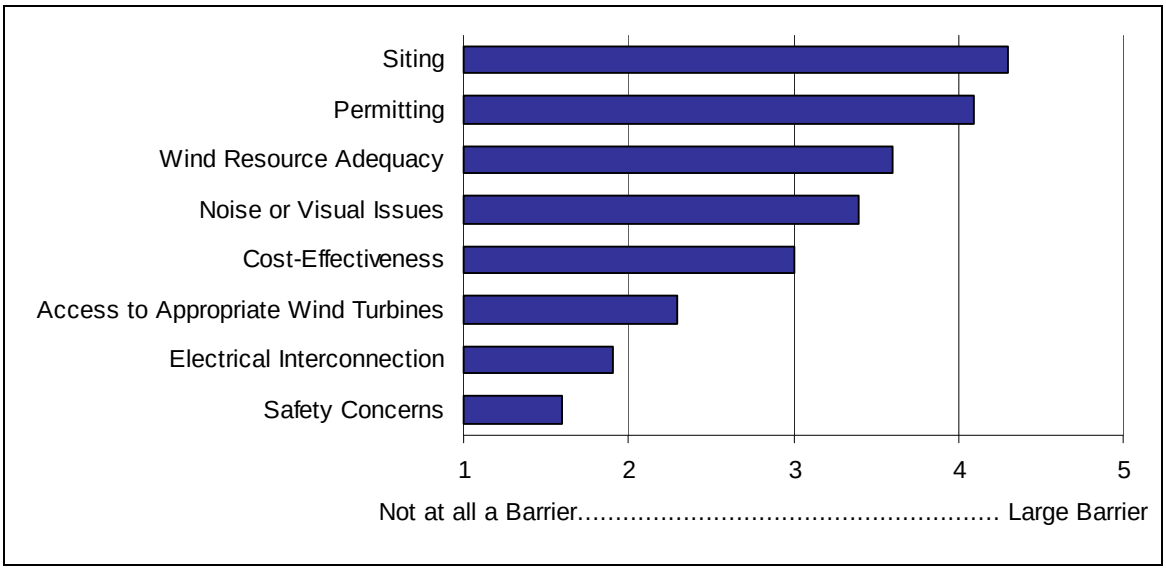
In general, small wind customers are satisfied with their systems. In fact, 68 percent of the customers who responded would purchase their system again. A few mentioned that they would even have a larger system. Eighty percent of respondents would recommend wind generating systems to others. For those dissatisfied with their small wind experience, the most common complaints included permitting cost and time, poor contractor competency, property tax increases, less-than-expected system performance and payback, and resource adequacy. Aside from these major complaints, there were minor concerns with warranty, retailer, ERP rebate, performance monitoring, and maintenance. These issues will be elaborated upon further in the next chapter.

CHAPTER 5: Market Barriers

AWEA projected that the creation of the federal Investment Tax Credit of 30 percent in 2008 would lead to an estimated 40-50 percent annual growth in the small wind market. Correspondingly, all manufacturers, retailer, and contractors that responded to the 2009 Energy Commission survey also expect small wind demand to increase in California anywhere from 20 to 100 percent. However, the expected increase in demand does not lead to an equal expectation in sales increase. Most expressed a belief that sales would increase by a much lesser percentage than the expected increase in demand or even stay the same. In fact, one retailer/contractor estimated that wind sales would decrease by 50 percent. This mismatch in expected demand versus expected sales is due to a myriad of market barriers, including permitting, siting, system performance, equipment reliability, and costs. These barriers will be described from the supply-side perspective (manufacturers, retailers, and contractors) and the demand-side perspective (wind customers).

In the 2009 Energy Commission survey, KEMA asked manufacturers, retailers, and contractors to rank a list of barriers to selling a small wind turbine or bringing a small wind project to completion. The suppliers invariably rank siting and permitting as the major barriers and electrical interconnection and safety concerns as minor barriers.[15]

Figure 5-1: Barriers in Completing Wind Projects[16] (Supply-Side Perspective)



Source: Small Wind Installer/Manufacturer Survey

[15] On the demand side, no customer mentioned difficulty in getting their system interconnected; only one customer mentioned safety concerns about blades being damaged at high winds.

[16] The data in this graph is compiled from the 10 survey responses received from 8 contractors and 2 manufacturers. For Noise and Visual, Cost Effectiveness and Payback, and Safety Concerns, the rating averages are taken from all respondents. For all the others issues, such as siting and permitting, the averages are taken only from contractors, and not manufacturers.

The following sections would describe these supply-side barriers experienced from contractors and manufacturers, as well as issues and concerns experienced by small wind customers. Some of these issues include product performance and reliability, maintenance and monitoring, contractor and retailer quality, warranty, project financing, and utility billing.

Siting

According to the contractor/manufacturer survey, siting wind turbines is the largest barrier in project development. Siting is a general term for assessing whether a site is appropriate for wind development. The process includes assessing a site for its adequacy in wind resource, determining whether the turbine might have significant noise/visual impact to the neighbors and obtaining permits from local government. In the contractor/manufacturer survey, permitting, wind resource adequacy, and noise and visual impacts are all among the main barriers to wind development.

Permitting

According to the October 29, 2008 Small Wind Workshop report published by California Wind Energy Collaborative (CWEC), permitting is one of the biggest hurdles facing small wind. Currently, there is a wide range of requirements and fees from county to county. While some counties have adopted "reasonable" requirements and have a standardized permitting process, other counties, especially those that have only recently started to see interest in wind projects, do not yet have clear protocols to issue wind permits. Many counties have requirements that seem to prohibit installations, including expensive fees, large application packages, long wait times, and codes that are unclear, restrictive, and subject to Not In My Backyard (NIMBY) influence.[17] In these cases, the process is set up to weigh on the side of disapproval, not approval.

Permitting time and costs vary widely between counties and, in some cases, within a county. In the 2009 survey, retailers and manufactures were asked about their experiences with permitting small wind systems. Permitting time is reported to take between 10 hours in Kern County to 18 months in San Bernardino County; and costs could range from less than $500 in Yuba County to over $10,000 in Shasta County. In addition, according to a CWEC contractor survey[18] in 2009, contractors indicate that there are many instances when unexpected costs are added to the

[17] In the October workshop, Guasti Construction presented a sample of these permitting requirements, including low building height (35 feet), public/private meetings, long periods of public comments, installing visual screens (that would end up blocking wind), installing fences/climb-guards, and planting trees that require another set of permitting requirements and fees.

[18] Johnson, et al., *Permitting Fees for Small Wind Turbines in California Counties*, California Wind Energy Collaborative, March 2009.

permitting fees. Unexpected costs may include labor fees, non-refundable deposits, public hearing printing costs, environmental evaluation fees, and others.

In the 2009 Energy Commission survey, suppliers were asked to rate the difficulty of obtaining permits in the counties in which they operate, with 5 being the most difficult and 1 being the easiest. Of the 23 counties in which the survey respondents operate, more than half rated permitting difficulty as 4 or 5, with San Diego County and Imperial County as two of the most challenging. Only a handful of counties received a rating of 1 or 2 for being the easiest to obtain permits; Yuba, Butte, Kern, and Glenn counties are reported to have relative fast and reasonably priced permits. Table 5-1 lists the difficulty rating, time, and costs of obtaining building permits in the 23 counties or cities with which the survey respondents have experience.

Table 5-1: Permitting Time and Costs by City or County

County/City	Difficulty Rating[19]	Time	Cost[20]
Amador/Fiddletown	3	3-4 weeks	-
Butte County	2	3 weeks	$515
City of Carmel	5	50 hrs	>$5,000
City of Buellton	5	-	$13,500
City of Redding	5	10-12 weeks	>$1,000
Contra Costa County/City of Oakley	3	3-4 weeks	$191
Glenn County	1	4 weeks	$850
Imperial County	5	8 months	$4,000
Kern County	2	10 hrs	<$1,000
Klamath County	3	3-4 days	$600
Lancaster County	5	50 hours	>$10,000
Los Angeles County	5	40-50 hrs to >9 months	$1,100 - $7,000
Napa County	5	6-8 weeks	-

[19] In the 2009 Energy Commission survey, suppliers were asked to rate the difficulty of obtaining permits in the counties in which they operate, with 5 being the most difficult and 1 being the easiest. When multiple ratings are shown on the table, this means different suppliers have varied experiences within the county.

[20] The cost data presented in this table is a compilation of self-reported data from survey respondents. The data is not normalized for system size or cost of installation.

County/City	Difficulty Rating[19]	Time	Cost[20]
Riverside County	4-5	40 hours to 9 months	$4,000 - $12,000
San Bernardino County	1-5	10 hours to >7 months[21]	$450- $1,000
San Diego County	4	12 visits/3 months	$4,000 to $10,000
San Luis Obispo County	-	-	"Impossible"
Santa Barbara	4	40 hrs	>$5,000
Shasta County	5	8-12 weeks	$1100, >$10,000
Solano County	2-3	3-4 weeks	$1,200
Tehama County	1-3	3 days to 3 weeks	$500-$800
Yolo County	3-5	3-8 weeks	$1,500
Yuba County	1	1 day	$450

Source: Small Wind Installer/Manufacturer Survey

In the customer survey, customers on average report feeling rather neutral about the permitting process; this is possibly because contractors usually handle the permitting paperwork. However, 15 percent of the customers reported that they are "not at all satisfied" with the permitting process. In fact, it is the most commented upon issue in the Energy Commission customer surveys. This is because some customers, especially owner-installers, handle the local permitting themselves and have to suffer the delays, costs, and code restrictions[22] from the local governments. It is also important to note that the customers surveyed are the ones who have actually completed systems in the ERP; it is conceivable that there are many more potential wind customers in California who cannot complete their wind systems because of local permitting issues. In fact, some contractors commented in the surveys that some systems were never completed because of permitting issues.

Resource Adequacy

Small wind turbines operate optimally at a limited range of wind speeds; therefore, it is important to site a small wind system where there is adequate wind. In the Energy Commission survey, contractors and retailers on average identified resource adequacy as an average to large barrier. On a scale of 1 to 5, where 5 is a "large barrier" and 1 is "not a barrier at all," the average response for resource adequacy is rated at 3.6.

[21] It has been reported in the CWEC October workshop that it could take 18 months to be issued a permit.
[22] Two customers commented that the local codes limit the height to 28 and 33 feet, respectively, thereby preventing installation of a more efficient system.

In addition, ERP customers listed resource adequacy as one of their top five complaints in the 2009 Energy Commission ERP customer surveys. Half of the dissatisfied customers commented that there was insufficient wind in their area, and their system output was compromised. The other half commented that the wind system would go into standby when the wind was too high; therefore, they were not able to take advantage of the wind when it was most abundant.

Optimally, wind contractors could monitor a site for a year before determining its wind adequacy. However, since such an endeavor significantly adds costs (at least $5,000) and time to the project, it is not feasible for the individual projects to establish site-specific wind speeds overtime. In lieu of such data, installers rely on public wind resource maps that provide averages of regional wind speeds. National Renewable Energy Laboratory publishes a California wind resource map at 50 meters above ground in 2003. The Energy Commission last updated its wind maps for different hub heights in March 2007 using 2006 field data and historical weather data. Most wind maps are measured at higher altitudes for identifying utility-scale wind development opportunities; the wind map most relevant to small wind systems is one at 30 meters above ground published by the Energy Commission.[23] However, small wind towers could be as low as 10 meters, so the current wind map at 30 meters provides a poor proxy for turbines destined at lower heights.

In addition, wind maps only provide a general picture of annual wind resources across California regions; it does not provide seasonal, monthly, or daily variables, nor does it evaluate wind resources at a specific site. The actual wind speed at a site is greatly influenced by the local topography and nearby obstacles such as trees or other building structures. Not only do these obstacles reduce wind speed and its consistency, they may cause wind direction to shift erratically. All these factors make the task of estimating wind resources difficult. Inaccurate estimates of wind speed ultimately lead to false performance expectations.

As detailed in the recommendation chapter, resource estimation could be improved by lower elevation wind maps coupled with siting guidelines, siting training, and, potentially, an on-line estimation tool. There is a huge amount of uncertainty in small wind siting that will never be able to be addressed cost effectively, especially in urban environments; therefore, some risk-taking is expected.

Noise and Visual Issues

Technological advances continue to improve the noise level and aesthetics of small wind turbines. AWEA maintains that sound and visual impacts are negligible for most small wind installations, that is, indistinguishable from background noise at 300 feet or less. However, in a 2004 study by NREL[24], the authors find that noise levels of small wind turbines vary: some turbines (Bergey Excel turbine with newer SH 3052 blades, Bergey XL.1, and Southwest

[23] NREL is also planning to publish resource map at 30 meters in the future.

[24] Migliore, P., J. Van Dam, A. Husky, *Acoustic Tests of Small Wind Turbines*, National Renewable Energy Laboratory, 2004.

Whisper 100) have noise levels of less than 6 A-weighted decibels above background noise levels at all wind speeds above 7 meters per second, while others (Southwest AIR 403 and AIR X) become much noisier in high wind conditions. This point is echoed by some customers who responded to the Energy Commission survey.

In the Energy Commission manufacturer/installer survey, respondents identified visual and noise issues as "somewhat a barrier." In the rating of 1 to 5, where 5 is a "large barrier" and 1 is "not a barrier at all," noise and visual issues rated on average at 3.6. In the customer survey, nine customers wrote in complaints about the noise level of their turbines, especially during high winds.

Since respondents to the Energy Commission surveys are wind industry participants, they generally find the noise and visual issue acceptable. These issues are more pronounced among building departments and communities that contribute to the difficulty in obtaining permits. In the customer survey, two respondents mention complaints from neighbors: one of them complained about excessive noise, causing the owner to run the turbines for only 10 hours per year; the other complaint was launched during the permitting process, causing a six-month delay in obtaining the permits.

Costs

Cost is a major component of cost-effectiveness of a small wind system. All the manufacturers, contractors, and retailers who responded to the survey agreed that costs in the past five years have increased between 10 and 28 percent. The increases are mostly due to increases in hardware, installation, and permitting costs. Since wind turbines rely on steel and concrete for their structures, the costs are tied to the increase in commodity price over the past few years. In addition, one contractor mentioned sales tax increases contributing to increased installation costs.

Manufacturers of solar photovoltaics are showing promise in developing significantly cheaper and more efficient solar modules. Wind manufacturers, on the other hand, cannot rely on technological breakthroughs for significant future price reductions. Most modern wind turbines are highly efficient and function in approaching the physical limit of extracting energy from the wind. The remaining barriers keeping small wind systems from becoming a "mature" technology lie not so much in the basic technology, but in the system design, mainstreaming of design, and maturation of manufacturing. A significant reason for the variation in current small wind technologies comes down to system siting, specifically:

- Matching production with load.
- Specifying and locating a tower height and type.
- Designating a wind turbine for a site's specific wind conditions.

Unlike solar photovoltaics, where system capacity can be tailored based on the number of installed modules, these factors in small wind systems require a wide range of system sizes and designs to appropriately serve a load at the site.

Small wind systems, by nature, have a much lower applicability to a location than photovoltaics. Only a small fraction of households and businesses are located in an area with sufficient wind conditions. Of these, even fewer can support the space and siting requirements required for good operation and for fulfilling permitting requirements. Because of this, small wind does not have the same technical penetration potential as photovoltaics. Small wind manufacturers are therefore selling turbines on a more limited scale than photovoltaics manufacturers. This results in fewer economies of scale, leaving small wind systems currently short of mass production.

The cost fluctuations over the last 10 years mirror trends seen in the utility-scale wind industry; prices dropped through the early 2000s as manufacturers matured and then began to rise as material and energy prices rose and demand often outpaced supply. The trend for wind system cost increases culminated in a price peak immediately preceding the economic crisis of late 2008. Whether small turbine prices will fall along with other commodity prices is yet to be seen. The utility-scale wind market has recently seen the increased supply come in line with a slightly decreased demand resulting from the economic crisis. Increased manufacturing and a higher number of market players has helped reduce costs. The small wind market is much smaller than the utility-scale wind market in terms of manufacturing capacity and the number of market players. This offers potential for price stabilization and reduction as new manufacturers enter the market.

The other component of the cost-effectiveness equation is system performance. This will be addressed in the following chapter. Since cost-effectiveness and system performance are important factors in a customer's purchasing decision, the next topic is devoted to these issues.

System Installation and Performance

A small wind system is designed with two primary performance criteria:

- To perform with reasonable output for designated wind conditions.
- To perform for a lifespan of 15 to 30 years.

The survey addressed both of these performance criteria to assess how installed small wind systems in California were stacking up against equipment, siting, and installation standards.

Since all wind systems in consideration for this survey have been installed after 1998, no systems have yet met their design lifespan. However, some of the older systems might have experienced early failure due to equipment aging. Of all respondents, 90 percent reported that their system is still in operation, as shown in Table 5-2. Of the systems no longer in operation, eight respondents provided the causes, including:

- Destruction by high winds (3)
- Removal due to court order
- Removal because of poor winds
- Removal because of high winds
- Turbine failure
- Inverter failure

Table 5-2: Operational Systems

Is system currently operational?		
Yes	109	90%
No	11	9%
Other	1	1%

Source: ERP Small Wind Customers Survey

The respondents were also asked to provide qualitative impressions of system performance. When questioned about how they felt their system performed, nearly one half reported that the system performed as expected, as shown in Table 5-2. The remaining respondents were nearly split on whether their system performed better or worse than expected. Because this question addressed more qualitative feelings about the system, there is no means of addressing whether the respondent was referring to reliability, energy production, or overall impacts (including acoustic impacts). In total, 69 percent of respondents found expected or better than expected performance from their small wind system. The 27 percent of respondents who reported worse than expected performance included respondents whose systems were producing nearly no energy at all as well as those that were simply producing somewhat less than initial estimates.

Table 5-3: Experience With System Performance

How has your system performed?		
Better than expected	25	21%
As expected	58	48%
Worse than expected	33	27%
Don't know	3	2%
Other	2	2%

Source: ERP Small Wind Customers Survey

Owners of all systems, whether currently operational or not, were asked to identify any and all problems that they experienced with their system. These problems are presented in Table 5-4. The participants were allowed to identify multiple problems. There were significant problems in all categories, except for problems with the warranty. Of the 121 survey responses 17 percent reported electrical problems, 20 percent reported mechanical problems, and 26 percent reported

problems associated with low wind. Only 32 percent of respondents reported that there were no problems with system performance at all, while over two-thirds reported a problem of some kind with about one-quarter reporting low wind. This issue has generally little to do with the technology or the installation, but rather siting the wind turbine to a specific location or too low of a tower. Although wind conditions for small wind turbines are difficult to quantify, this is a significant proportion of systems that have performance problems due to siting.

Table 5-4: Reported System Problems

Problems with system?		
Mechanical	24	20%
Electrical	21	17%
Low wind	32	26%
Warranty issue	5	4%
No problem	39	32%
Others	37	31%

Source: ERP Small Wind Customers Survey

Respondents also reported 37 other problems, which did not fit into the given categories. Some of the installation and performance problems include:

- Early turbine cutout in high winds (4 respondents)
- General inverter problems (5)
- Structural mounting failure (2)
- Excessive noise.

Of all the reported problems, respondents were asked to describe how their issues were resolved. Some major themes were noted from this question. First, most equipment failures were addressed under warranty at no cost to the participant (21 responses). On the other hand, 26 respondents mentioned that their issues were not resolved, including 9 that stated that poor wind conditions could not be resolved. Other indicative responses included:

- Threats to sue installer until action is taken
- Repairs by system owner, at owner's own cost (4 responses)
- Owner paid for upgrade (2)
- Switched system to solar
- Resolved issue at no cost to anyone (2)
- Turbine usage curtailed
- Utility did repair
- Battery back-up was removed
- Neighbors became accustomed to the noise

- Began to accept noise levels
- Problem resolved itself with time.

Product Reliability and Performance

Currently there are no requirements in the *ERP Guidebook* to verify performance claims from wind turbine manufacturers. When a manufacturer applies for ERP listing, he or she will submit either: certification to an appropriate wind turbine standard (such as International Electrotechnical Commission (IEC) 61400-2) or 12 consecutive months of output (kWh) data in a 12 mph or better wind site. The 12 consecutive months of output is self-reported by the manufacturer with no requirement for third-party verification.

In addition, all manufacturers are required to submit performance curves for their products. KEMA, the Energy Commission's technical contractor, verifies the product's rating falls on its performance curve. In the ERP Guidebook, there is no requirement for third-party verification of performance curves. In at least one case (PacWind), the validity of the supplied performance curves have been challenged by other manufacturers and even by former employees. PacWind products remain on the Eligible Equipment Listing since the information submitted meets the ERP requirements as currently defined.

IEC 61400-2 is a very rigorous certification standard. It includes power performance, durability, acoustic noise emissions, and safety of wind turbines protocols. The standards' mandated duration test requires at least 6 months of operation and at least 2500 hours of power production. As a result, full certification to IEC 61400-2 standards can be expensive and time consuming (it can take over a year). At least three manufacturers of new wind turbine products, who have contacted KEMA wishing to have their products listed on the ERP, subsequently investigated IEC certification but determined the time and expense was prohibitive. The three manufacturers are Windation, Windterra, and Aerovironment. Of the three, Aerovironment has since obtained 12 consecutive months of output data in a 12 mph or better wind site.

Most manufacturers on the ERP listing opt for self-reporting 12 consecutive months of output. This is not the most reliable option when considering product quality. Such a requirement is not considered an option for any type of known certification standard. Also most manufacturers would rather not wait for an entire year to get their products certified. In at least one case (Windterra) the product is not meant for such a high wind site (12 mph annual average). Their product is a small vertical axis turbine designed for mounting on the top of a residential roof ridge, and designed to operate in lower wind sites. So obtaining a year of data in a 12 mph average wind site can be problematic.

Small wind product reliability limits retailers' and contractors' choices in the market. As mentioned, contractors who have installed a large number of systems tend to use the same manufacturer model with which they are familiar and find reliable. Very few contractors

venture beyond the top two or three products on the ERP eligible equipment list. For the few contractors who experimented with new products, complaints were cited about the products' durability[25], inflated performance ratings[26], and some were simply described as "junk."

In addition, the two main manufacturers in ERP, Bergey Windpower and Southwest, did not think the current certification process ensured quality and performance in small wind systems. The current eligible equipment list does not differentiate wind products that are certified by a third party and those that are rated with self-reported data. The Energy Commission does not have a mechanism to regulate manufacturers that exaggerate their products' performance and therefore may unintentionally give an unfair advantage to poor performers.

System Maintenance and Monitoring

Small wind system maintenance was also a topic of the survey. When asked about who, if anyone, maintains the system, one-third of participants replied that they performed the maintenance themselves. Another 27 percent of the respondents mentioned that the system was not maintained, generally because the system did not currently need maintenance. The results are presented in Table 5-5. In total, 73 percent of respondents reported that their system was maintained.

Table 5-5: Responsibility for Maintenance

Who performs maintenance?		
Maintain the system myself	40	33%
Maintenance package through installer	22	18%
Maintenance by hired contractor	26	21%
System not maintained	33	27%

Source: ERP Small Wind Customers Survey

Performance of the small wind systems, which is often related directly to energy production, is generally monitored through meter readings. Table 5-6 shows the method of monitoring energy production. Most respondents (73 percent) manually read their meters either regularly or periodically. Only 14 percent of the survey participants reported that they do not track production. The fact that most respondents manually read their meters bodes well for later questions in the survey, where respondents were asked to estimate their annual energy production.

[25] REDriven products were reported to be unreliable and not durable for more than a year.
[26] PacWind

Table 5-6: Method for Energy Monitoring

Method of production monitoring		
Automatic system	15	13%
Regular manual readings	43	37%
Periodic manual readings	41	36%
Do not track production	16	14%

Source: ERP Small Wind Customers Survey

Small wind system performance and maintenance issues are crucial for ongoing success of small wind development. Since 1998, 90 percent of the systems installed are operational. There appears to be significant staying power for wind systems in California. At the same time, there have been significant problems experienced with wind turbine operation and performance for 68 percent of the respondents. Through what seems like persistence of the operator and a commitment to equipment warranties, many of the equipment issues have been resolved to keep the vast majority of turbines in the field. Some of the issues noted are rooted in problems inherent to the turbine technology or wind turbine performance in general, though some are directly related to poor siting decisions on the part of the installer. These issues could be directly addressed through increased availability of siting resources, including guidelines (including impact of tower height), best practices, and improved low-level (10–30 meter) wind maps.

Respondents appear to be willing to organize or perform maintenance on their systems as needed. The large majority of participants are also monitoring their energy production, through either an automatic system or through manual meter readings. Overall, approximately three-quarters of respondents are seeing turbine performance equal to or better than expectations. This does not, however, negate the less-than-expected (and sometimes very poor) performance of some participant systems.

Property Tax

Installing on-site renewable generation systems, assessed as property improvements, increases the value of one's property and, therefore, increases the property owner's tax liability. Unlike solar systems[27], small wind turbines are not exempted from these taxes. Some customers seem to be unaware of the property tax or the extent of its impact when they make the turbine purchasing decision. At least 10 percent of the respondents commented that property tax was a major issue. The magnitude of increased property tax often offsets many of the wind system's benefits. In one case, a customer claimed that the additional property tax outweighed the energy savings and federal ITC benefits combined.

[27] Assembly Bill 1451 (Murray, Chapter 538, Statutes of 2008) exempts solar property installed between January 1, 1999, and December 31, 2016, from property tax.

Retailer and Contractor Quality

As mentioned in previous chapters, most customers were satisfied with their retailers and contractors. Even so, a few incompetent or irresponsible providers could significantly give the small wind industry a bad name and affect consumers' confidence. Two customers reported that they ended up installing the wind system themselves because of issues with the original contractor—one of the contractors was reported to have quit before project completion. A handful of customers complained about the competency of their contractors, citing poor expected performance estimates, poor resource assessment, unwillingness to provide maintenance, and unwillingness to process rebate paperwork.

Warranty

Systems rebated under the ERP are required to have a five-year equipment and installation (labor) warranty. There were a few cases that a contractor went out of business before warranty expiration and the customer had to find and pay another contractor to perform repairs. In fact, this has been an issue in the solar industry for many years where no solution has been found. As the wind industry grows, some small manufacturers and contractors will enter the market. Like the solar industry, this warranty issue is expected to exacerbate as some of the fledging businesses might not stay in business long enough to fulfill all of their obligations.

In addition, some customers are concerned about their systems' warranty after the first five years. If a customer fails to upkeep his/her system after the warranty expires, California ratepayers who partially sponsor these systems will not receive the full benefits of the distributed renewable system.

Financing

Financing conditions have changed drastically in the United States in the past year. As equity dissolved from homes and bank losses mounted, it could become more difficult for potential wind customers to obtain financing to pay for the wind systems. This issue is mentioned by one of the contractors in the ERP.

Utility Billing

All ERP customers are required to be net-metered; customers receive an annual trued-up bill from their utilities that states the net generation and consumption balance. A few customers complained that the utility bills were impossible to understand because they were unable to separate generation data from consumption data. In fact, a net-metering bill does not have the ability to separate consumption data from generation data.

Existing law provides that the utility retains all net excess generation during the 12-month net metering period, and the customer is not owed compensation for those excess kilowatt-hours. Some customers would like to be paid for their annual net generation surplus instead of

forfeiting the surplus energy to their utility. This would require a legislation change. Currently, two bills (Senate Bill 7 and Assembly Bill 920) are in the Legislature that would require the electric utility to offer a standard contract or tariff to eligible customers that compensates them for the value of the net surplus electricity. If the legislation is passed, the economics of the system would be more favorable, and the market might see larger systems.

CHAPTER 6: Performance and Economic Analysis

There are few studies that have evaluated the performance of small wind turbines independent of the manufacturer's participation. Four studies that evaluate small wind turbines performance are identified in this report:

- The National Renewable Energy Laboratory (NREL) studied the performance of six Bergey 10 kW turbines installed at different sites in the Pacific Northwest.[28] The study found that five of the six sites estimated annual production far exceeded the actual production. Part of the discrepancy was attributed to start up issues with equipment. For some sites, wind resources were below those expected due to the use of generalized wind maps. Turbine placement behind obstacles also caused turbulence at one site which impeded energy production.
- A North Carolina turbine performance study[29] found that multiple equipment failures led to considerable downtime for five of six turbines at a high wind site. Manufacturers' power curves also fell short of measured power performance for some models.
- In 1999 five small wind turbines were tested at the Wulf Test Field in the Tehachapi Mountains, California.[30] The results found that none of the turbines consistently attained their advertised power curve at all wind speeds.
- A 2008 Cadmus report studied the performance of 19 small wind projects (10 kW or less) funded by the Massachusetts Technology Collaborative (MTC)[31]. Among other conclusions, the report finds that the average capacity factor for the 19 is 4 percent, less than half of the target capacity factor of 10 percent; installers, on average, overestimate energy generation by a factor of 3 to 4; and the cause of the overall poor performance of installed small wind energy systems is not known with complete certainty, but known contributing factors include inverter synchronization/standby time, higher than expected site turbulence, and lower than expected average wind speeds.

There are relatively few studies that have attempted to evaluate the performance of residential scale small wind turbines. The MTC report by Cadmus Group is the only study that assessed turbine performance as part of a state renewable energy incentive program. All the systems in the study had rated capacities under 10 kW. The study's performance analysis focused on evaluating and confirming a wind system's capacity factor. The capacity factor is defined as:

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[28] Sinclair, Karin, *Regional Field Varification – Case Study of Small Wind Turbines in the Pacific Northwest*, National Renewable Research Laboratory, 2005.

[29] Summerville, Brent, *Small Wind Performance in Western North Carolina*, Appalachian State University, 2005.

[30] Gipe, Paul,"Testing the Power Curves of Small Wind Turbines," *WindStats Newsletter* (Vol. 13, No. 3), 2000.

[31] Shaw, Shawn, *Progress Report on Small Wind Energy Development Projects Receiving Funds From the Massachusetts Technology Collaborative (MTC)*, The Cadmus Group, Inc, April 2008.

$$\text{Capacity Factor} = \frac{\text{Net Annual Energy Yield}}{\text{Rated System Capacity} \times 8760\, {}^{hrs}\!/_{year}} \qquad (1)$$

The capacity factor effectively reflects what percentage of the system's theoretical maximum energy output is produced each year. Utility-scale wind turbines are designed to operate most effectively with a capacity factor of between 20 percent and 35 percent. While well-sited small wind systems can achieve capacity factors above 20 percent, many small wind systems are estimated to achieve capacity factors under 20 percent. In general, small wind systems with a capacity factor of between 10 percent and 20 percent have provided reasonable economic returns when combined with net metering and state and federal incentives.

The average capacity factor for the 19 reporting turbines in the Massachusetts study was 4 percent, and only six met the program requirement of 10 percent. The study also found evidence of faulty manufacturer power curves and overestimation of annual energy production. The study speculated that poor performance was due to a lack of sufficiently accurate wind data during the design phase, poor siting (for example low towers, low wind speeds, obstacles, turbulence), and underperforming equipment such as inverters.

Performance Analysis

For small wind systems to emerge as a viable distributed renewable energy technology, small turbine performance must be consistent and sufficient to make a project financially viable with the use of state and federal incentives. The performance of the reported wind systems was analyzed in depth, in part to gain an understanding of whether systems were designed, sited, and installed properly, but also to better understand a system's payback.

In conjunction with the information obtained through the residential survey, KEMA accessed system specifications from the Energy Commission database, including:

- System capacity (watts)
- Installation date
- Turbine make and model
- Installed cost
- Rebate amount.

The survey respondents provided a significant amount of information regarding system performance, financial benefits, and their overall impressions about their system. In regard to system performance and economics, KEMA and the Energy Commission specifically inquired about:

- Estimated/recorded annual energy production.
- Estimated/recorded cumulative energy production.
- Difference of annual household electricity consumption.

- Difference in annual household electricity bills.

These multiple inquiries related to energy production were used to not only calculate annual production and savings, but to serve as a check for one value against the other.

The survey also addressed whether:

- Household energy consumption has changed significantly since installation.
- The system is still in operation.
- The owner would purchase the system again.

Since the provided performance information could not be verified, KEMA used several methods for determining validity of submitted information. KEMA first addressed reporting discrepancies for energy production and savings estimates. For values that were reported as a range, KEMA averaged these values if they lay within 50 percent of each other. Ranges with a span of more than 50 percent were rejected. Since multiple questions regarding energy production were asked, a rejected value would often not disqualify all of the respondent's estimates but rather default to the respondent's other estimates. For instance, if a respondent reported annual energy production of 4,500 kWh to 6,000 kWh, the value of 5,250 kWh would be used. If a respondent reported annual production of 100 kWh to 1,000 kWh, the value would be passed over in favor of other production estimates.

In estimating system capacity factor, KEMA first assessed estimates of annual energy production, namely:

- Reported estimated annual energy production.
- Annualized cumulative energy production.
- Estimated reduction in energy purchases (for cases where respondent reported no change in household consumption).

Not all participants responded sufficiently to determine all annual production numbers.

As a means to investigate consistency of responses, the standard deviation of all available annual energy production values was calculated. If this calculated percentage standard deviation was less than 20 percent (including 0 percent for single values), the calculated capacity factors were averaged. For values larger than 20 percent, KEMA investigated the participant's responses in detail in order to determine which, if any, of these values were accurate. Data cleansing of capacity factors was done using these methods:

- Automatically rejecting capacity factors greater than 40 percent.
- For capacity factors with the annualized cumulative production value as an outlier, the value would be rejected if the system had been in operation for less than a year. This

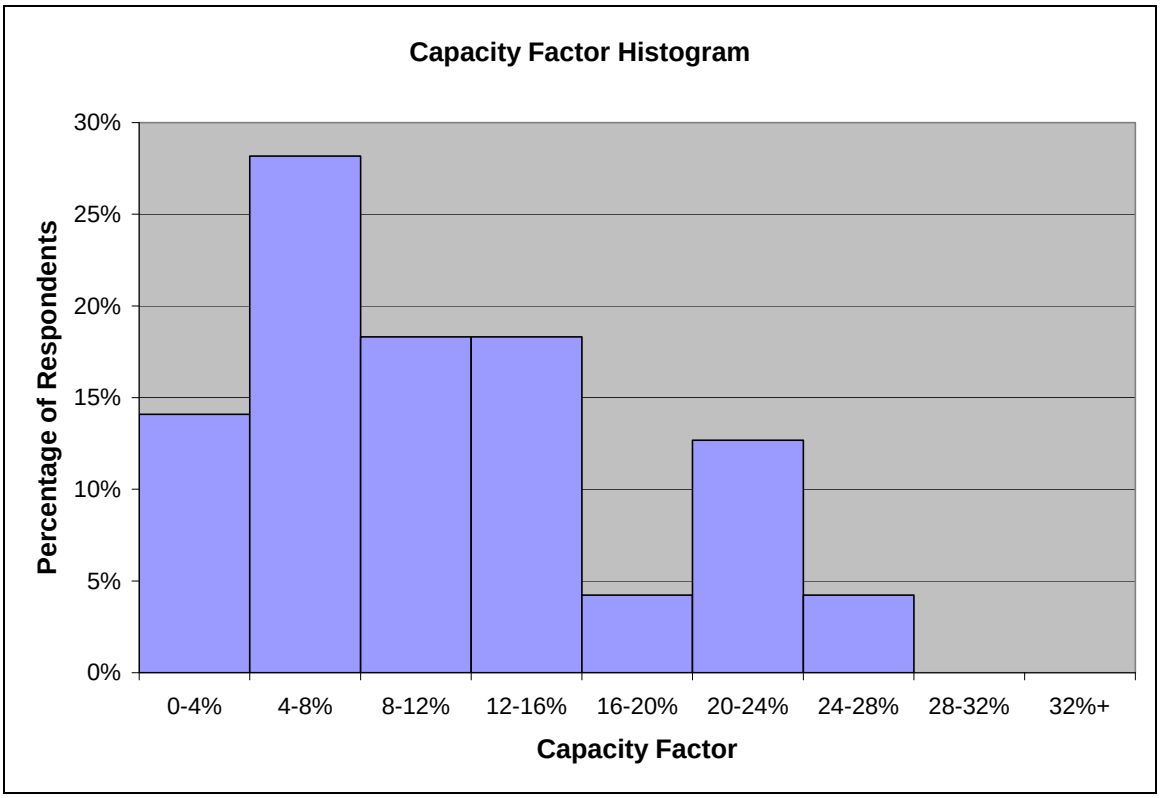
was done because the figure would not represent seasonal fluctuations or take into account discrepancies in operational start date and survey date.

- For discrepancies in reported annual change in energy consumption, the annual change in kWh consumption would be compared with the annual change in electric bill. For a range of possible per kWh charges, major discrepancies would result in rejecting of the capacity factor based on the reported change in annual energy consumption.
- Investigating reported comments about system performance. In some cases where there were order of magnitude differences in capacity factor, responses about customer satisfaction or expected payback would help differentiate a system with an "excellent" capacity factor from one with a "very poor" capacity factor.
- For remaining capacity factors with greater than 20 percent standard deviation, those lying in the lower capacity factor range (under 8 percent) were accepted if the capacity factors were reasonably close. This was done since these values reflecting poor performance were sensitive to the calculation of percent variations.
- Remaining significant discrepancies in capacity factor were removed from the data analysis.

Of the 121 respondents, 87 provided enough information to calculate a capacity factor. From those 87 participants with calculated capacity factors, 15 respondents were not included in the final analysis of 72 respondents.

The calculated capacity factors are presented in a histogram in Figure 6-1. The histogram reports capacity factor bins ranging from 0 percent to 32 percent. The capacity factors trend toward the mid-teens and below, with 25 percent of respondents reporting a capacity factor of between 4 percent and 8 percent. Small wind systems are generally sited with the intention of achieving a capacity factor above 12 percent, though some situations with capacity factors around 8 percent might be economically feasible. Systems with capacity factors under 8 percent are almost always improperly sited. In this analysis, 42 percent of turbines achieve a capacity factor of 8 percent or less.

Figure 6-1: Capacity Factor Histogram



Source: ERP Small Wind Customers Survey, calculations done by authors

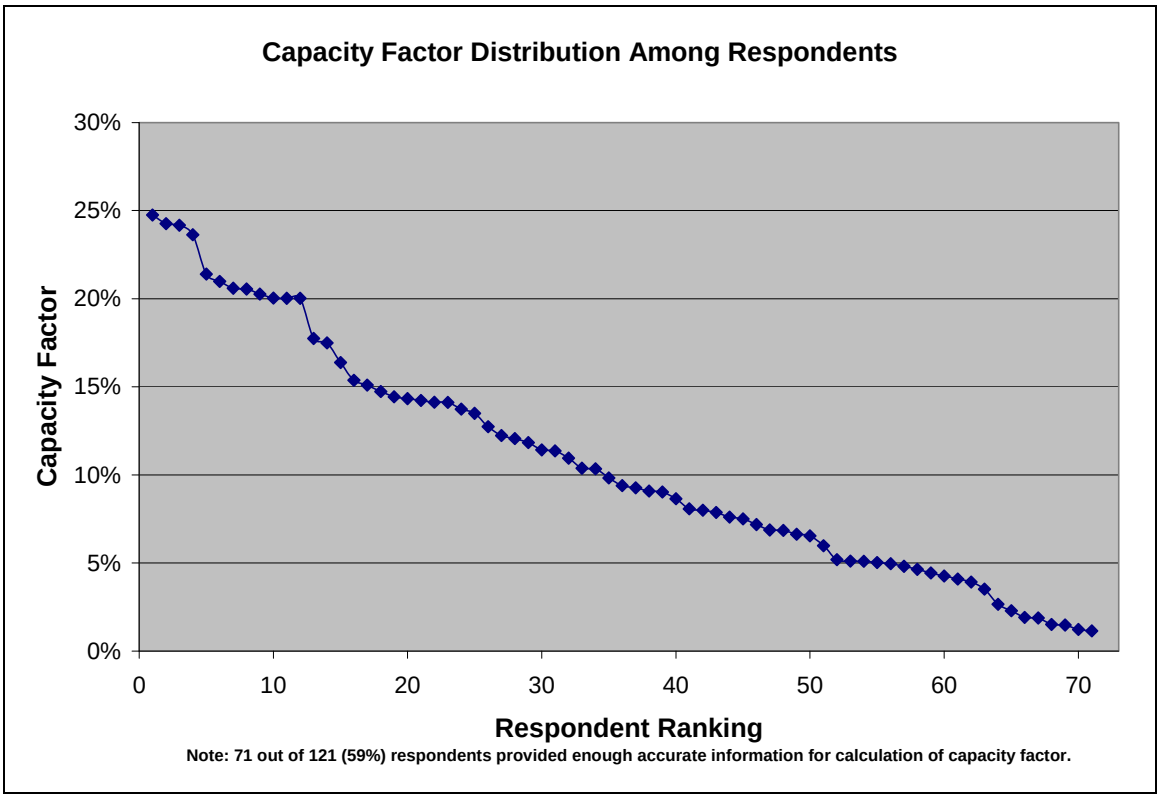
Table 6-1 shows the statistical representation of the sample of calculated capacity factors while Figure 6-2 represents distribution of capacity factors among respondents. The standard deviation and the range are significant. Of particular interest is the large number of respondents with capacity factors below 8 percent.

Table 6-1: Capacity Factor Statistics

Capacity Factor (CF) Statistics	
Average CF	10.7%
Median	9.4%
Standard Deviation [Absolute %]	6.6%
Range	1.2% - 24.7%
Respondents Included	71.0%

Source: ERP Small Wind Customers Survey, calculations done by authors

Figure 6-2: Capacity Factor Distribution



Source: ERP Small Wind Customers Survey, calculations done by authors

Observing a large range of capacity factors is not unusual with wind systems of any size. Each turbine and each location are designed differently. Unlike solar systems, small wind systems must take advantage of the local weather conditions and cannot be expected to perform at a given level for any part of the state. Nevertheless, the capacity factors for these small wind systems vary significantly. The mean capacity factor of 11 percent is in an acceptable range of small wind capacity factors, though many participants would likely be seeking a higher value. However, standard deviation of the capacity factors (7 percent absolute) is very large. This reflects the large spread of performance characteristics between those with excellent performance (18 percent or above) and those with dismal performance (4 percent or below). Furthermore, many systems are performing with capacity factors below 8 percent. These systems are generally a result of poor siting and equipment designation. Although these low capacity factors are almost commonplace in small wind programs, many of these sites can be avoided or improved upon through:

- Improved educational resources on siting.
- Improved educational resources on choosing an appropriate turbine.
- Improved access to low-level wind maps.
- Increased oversight and evaluation of contractors with poor siting records.
- Promotion of higher turbine hub heights through education and reducing permitting barriers.

Some aspects of poor performance can also be attributed to poor equipment performance of the turbine. With misleading power curves, incorrect designations of design wind speed or atypical cut-in/cut-out wind speeds, a turbine might be inappropriately designated for a site or simply of poor design.

Economic Analysis

At the heart of achieving a viable and reliable distributed renewable energy technology, emerging small wind systems must ultimately achieve and consistently prove to be a favorable investment. To be a financially viable technology, all incentives and production revenue/offset costs must, at the very minimum, offset the upfront costs by the end of the turbine's useful life (15–30 years). The attractiveness of a project's payback must be considered in relation to an alternative investment.

A project with a 20-year simple payback corresponds to a simple rate of return of 5 percent. However, the true payback of the project is dependent on the gradual devaluation of money and the future value of project revenues. When a discounted payback (represented by a discount rate of 5 percent) is taken into account, a 20-year simple payback translates into the system not ever paying for itself. A 10 year simple payback (or a 10 percent simple rate of return) is equivalent to a 14-year discounted payback, or a 7.2 percent discounted rate of return. The investment value of a small wind system should be seen in the context of alternative investments, both in potential rate of return as well as in risk. For a technology such as a small wind system to break through to rapid adoption and implementation, the investment should surpass others in terms of returns while offering little risk. For an investment to be attractive to potential project owners, the return and risk will have to be similar to other investments. Projects with returns lower than alternative investments (or with larger risks) will fail to attract the mainstream population and implementation will be largely limited to early adopters.

KEMA analyzed the respondent's financing and payback of their small wind systems, both through reported paybacks and calculated estimates of payback. The results show that the large majority (75 percent) paid for their systems with cash, while 22 percent at least partially financed the system, and only 2 percent leased the system. The results are summarized in Table 6-2 These results show that adopters are almost entirely shouldering the entire post-rebate cost of a system, either through cash or loans. This suggests also that the respondents perceive the systems as a capital investment—a purchase with a large upfront cost and a perceived payback. The low number of leased systems makes clear that there are no significant lease programs available for people unwilling or unable to make the upfront investment in a small wind system. The large number of respondents who reported paying cash suggests that owners are generally those with extra money available outside of other investments, rather than people who require a loan or home re-mortgaging to pay for the system.

Table 6-2: Payment Method

Method of paying for system		
100% Cash	91	75%
Leased	2	2%
Financed (Cash and Loan)	27	22%
Other	1	1%

Source: ERP Small Wind Customers Survey

The survey asked respondents directly what their expected payback was and also whether their payback expectations changed after purchasing their system. In addition to reported payback estimates, KEMA estimated system payback using annualized cost savings, system price, and rebate amounts. The ERP database provided information on system capacity, system cost, and rebate, which could be used in conjunction with survey data to calculate payback.

Respondents reported expected payback of their system in three categories:

- 5 years or less
- 6 to 10 years
- More than 10 years.

The responses are shown in Table 6-3. Most respondents expect their system to pay for itself in 6–10 years, while more than 30 percent expect a payback of over 10 years. Only 13 percent expect their systems to pay for themselves in 5 years or less.

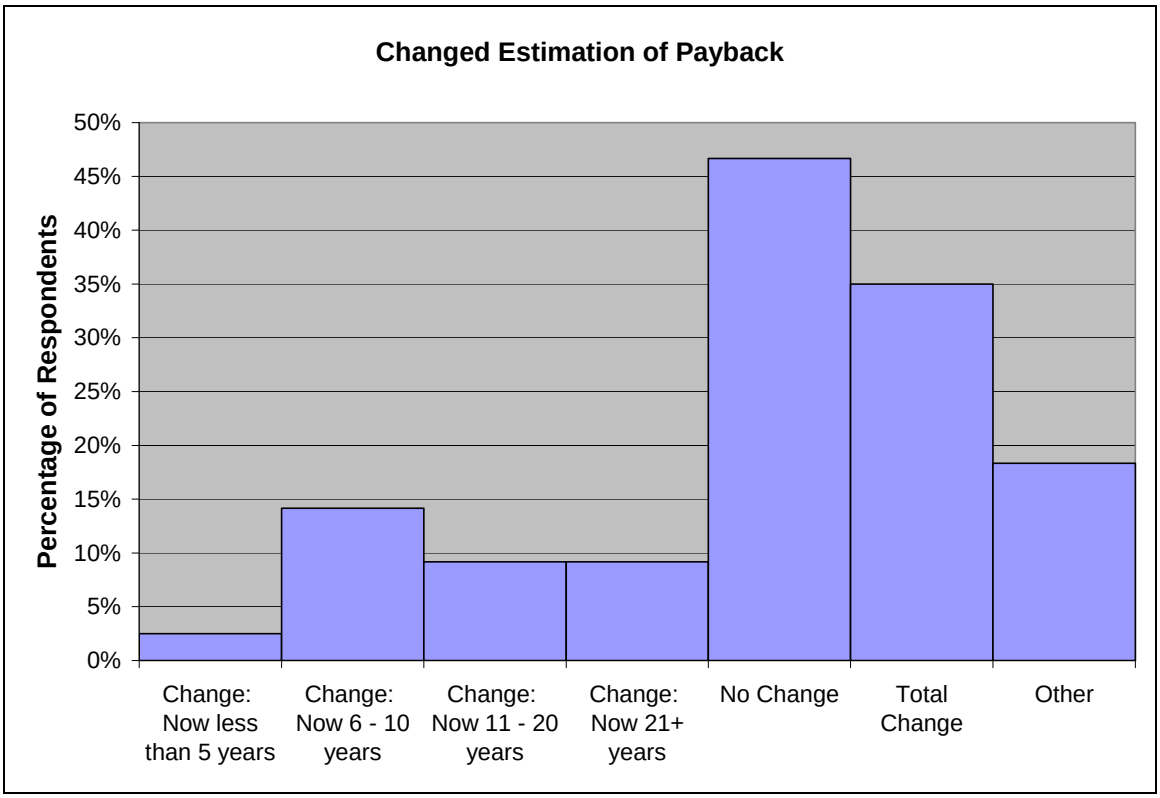
Table 6-3: Reported Payback Expectations

Expected payback of wind system		
5 years or less	16	13%
6–10 years	61	50%
More than 10 years	40	33%
Other	4	3%

Source: ERP Small Wind Customers Survey

Respondents were then asked if their payback expectations had changed and what were their new payback expectations. Responses indicate that 47 percent of participants did not have a changed expectation of payback, while 35 percent of respondents did report a change in expected payback. The reported changed expectations were skewed toward longer paybacks than the first estimates, as shown in Figure 6-3. Of particular note is that the distribution of new expected paybacks of 10+ years (including the 21+ year category) was significantly more than that in the original expectations.

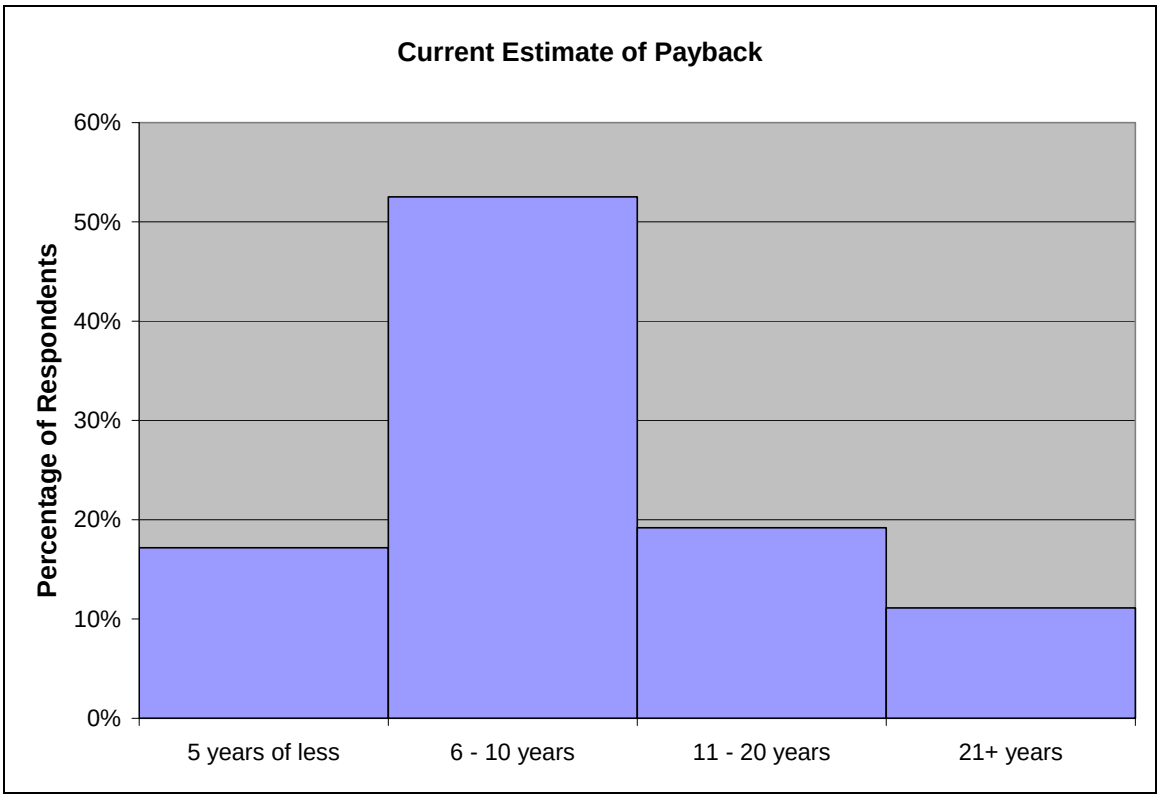
Figure 6-3: Changed Payback Estimate



Source: ERP Small Wind Customers Survey, calculations done by authors

The histogram of current payback estimates is given in Figure 6-4. This figure combines the updated payback estimates with the original estimates that were "not changed." The distribution shows that the large majority of systems are expected to have a payback of 20 years or less. Of special note, a majority of systems are expected to have paybacks of 10 years or less. On the other hand, 11 system owners were expecting paybacks over 20 years, with six owners expecting their payback only at 100 years (that is, not at all over the life of the system).

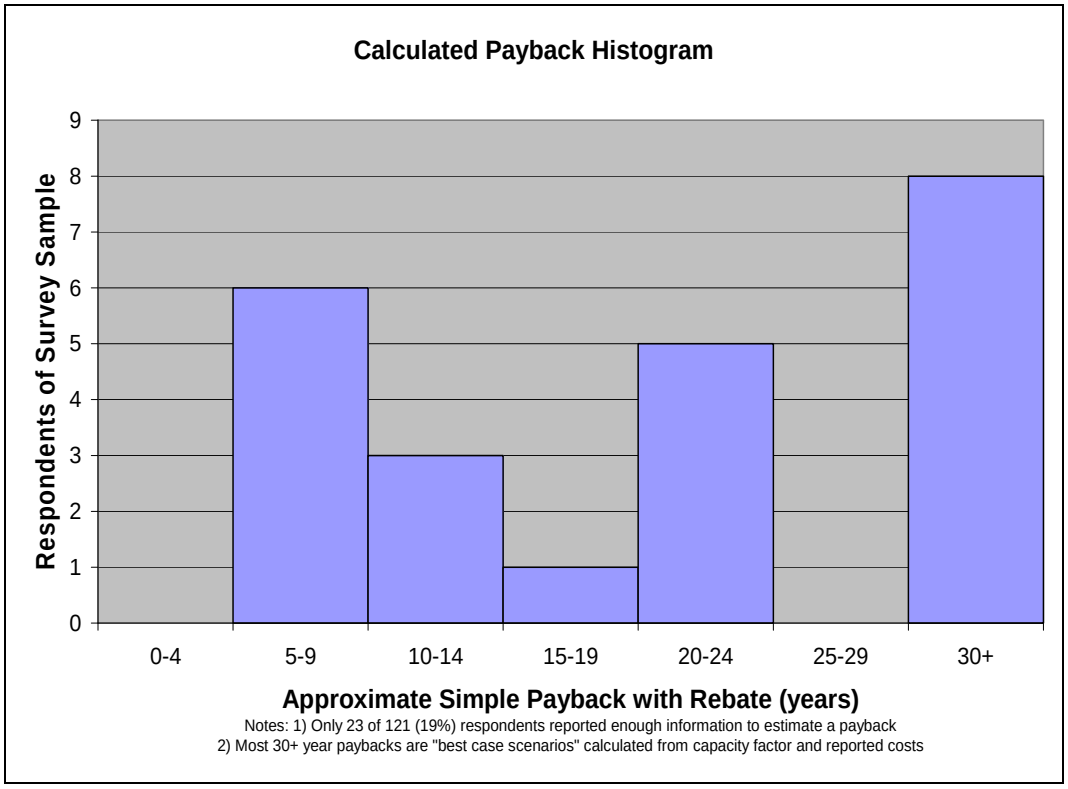
Figure 6-4: Histogram of Current Payback Estimates



Source: ERP Small Wind Customers Survey, calculations done by authors

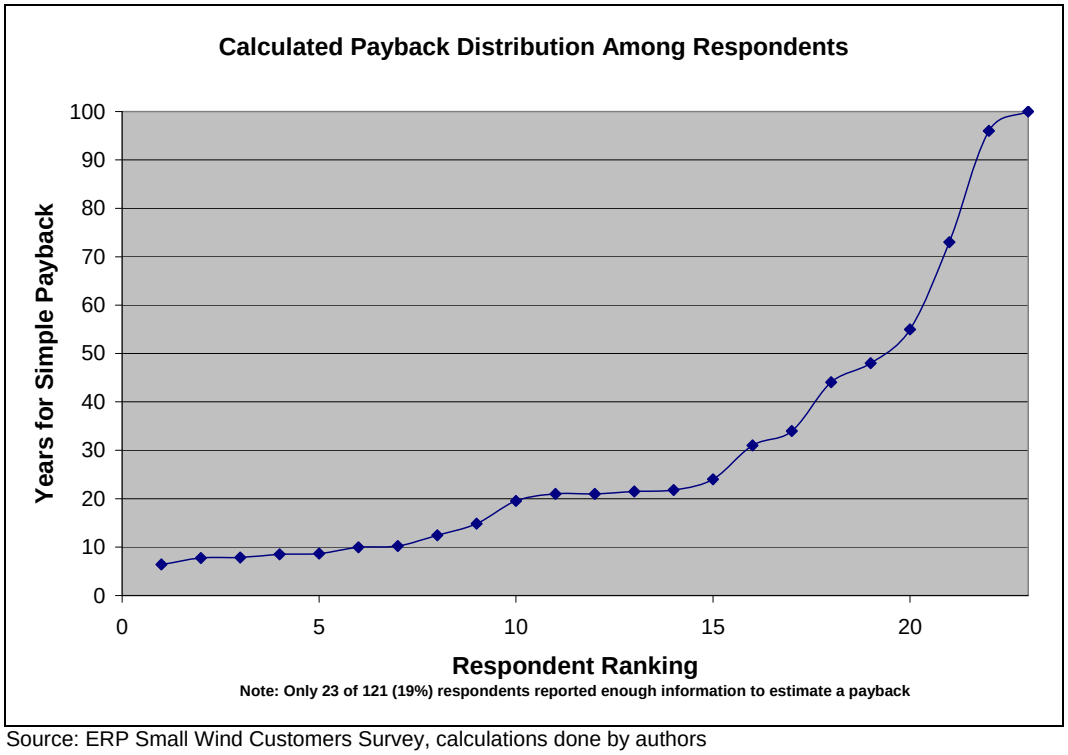
For survey respondents that provided sufficient information, KEMA calculated payback based on reported annual savings and upfront cost to the system owner. Note that this analysis did not include ongoing revenue outside of electricity offsets and sales nor did it include the incentives from the expanded ITC, as the expanded ITC was not in place for systems considering in the survey of all respondents, only 23 of the 121 provided enough accurate information that a payback could be estimated. The reported electricity savings were cleaned based on similar criteria as stated in the section describing capacity factor estimates. The calculated payback estimates are presented in Figure 6-5. Although the majority of respondents did not provide enough information to be included, some of the participants that provided enough information to determine that payback would be, under the most optimistic scenario, 20 years or more and were included in this representation. These best-case annual system revenues were calculated using the reported annual kWh production and the highest per kWh price that could be achieved. Because of that, there is a slight skew towards presenting the systems with the longest paybacks. The distribution of calculated paybacks is presented in Figure 6-6.

Figure 6-5: Calculated Paybacks



Source: ERP Small Wind Customers Survey, calculations done by authors

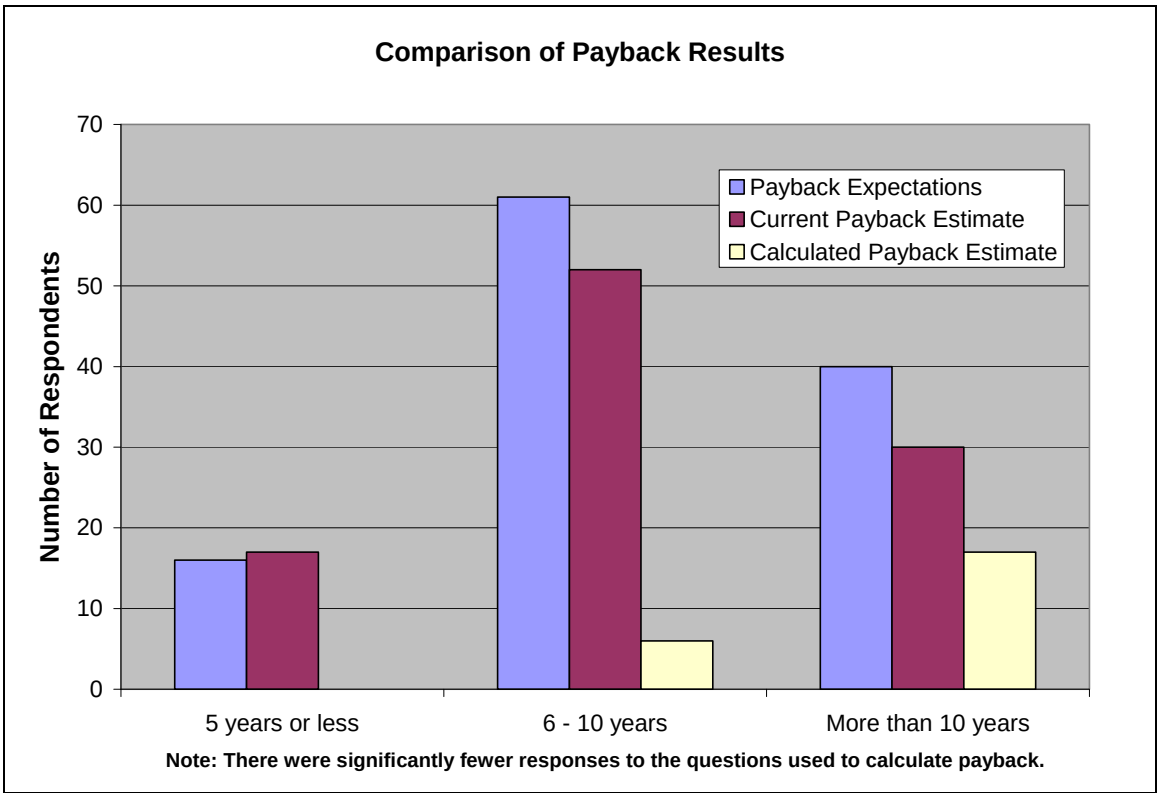
Figure 6-6: Calculated Payback Distribution



Source: ERP Small Wind Customers Survey, calculations done by authors

The three estimates of payback (self-reported, reported post-changed expectations, and calculated) are presented side-by-side in Figure 6-7. Note that the payback bins are based on total number of respondents and not the percentage who answered the question or could be calculated. The most respondents answered the first payback question, slightly fewer responded to the second, and far fewer provided enough information to calculate payback. This analysis reflects some of the inconsistency between reported paybacks and calculated payback while also showcasing the very limited accurate reporting of yearly savings from small wind systems. All in all, a limited number of respondents were confident that their system would provide a quick payback of 5 years or less, while a majority was expecting paybacks within 6–10 years. Through any estimate, there remains a significant portion of the respondents with expected or calculated paybacks of 10 years or greater. Some of these respondents were expecting paybacks of well over 20 years.

Figure 6-7: Comparison of Payback Expectation Results



Source: ERP Small Wind Customers Survey, calculations done by authors

The three payback values used (the two reported and one calculated) were compared side-by-side for respondents in an effort to judge consistency. For each respondent with paybacks either reported or calculated, the range and standard deviation were calculated for the three payback values. This range and standard deviation represents the consistency of the respondent's payback values. The reported statistics effectively show that 14 percent of the respondents had multiple payback values that resulted in a standard deviation above 10 years. The other 86 percent had a standard deviation of less than 10 years. This suggests that approximately 86 percent of the available payback figures were reasonable, while the other 14 percent either had

drastic changes in expected or calculated payback, or there was an inconsistency in the reported data. A portion of this discrepancy was a result of the calculated payback estimates, which comprised 47 percent of the payback range standard deviations above 10 years. This is partially a result of the 8 calculated paybacks of 30 years or greater. Of all respondents with payback values, the average range of those one to three values was 10.6 years. The average standard deviation of those one to three values was 7.0 years. This suggests that there remain some discrepancies between reported paybacks and/or calculated paybacks. Without on-site investigation of performance and additional reporting of annual savings, these payback values cannot be further verified.

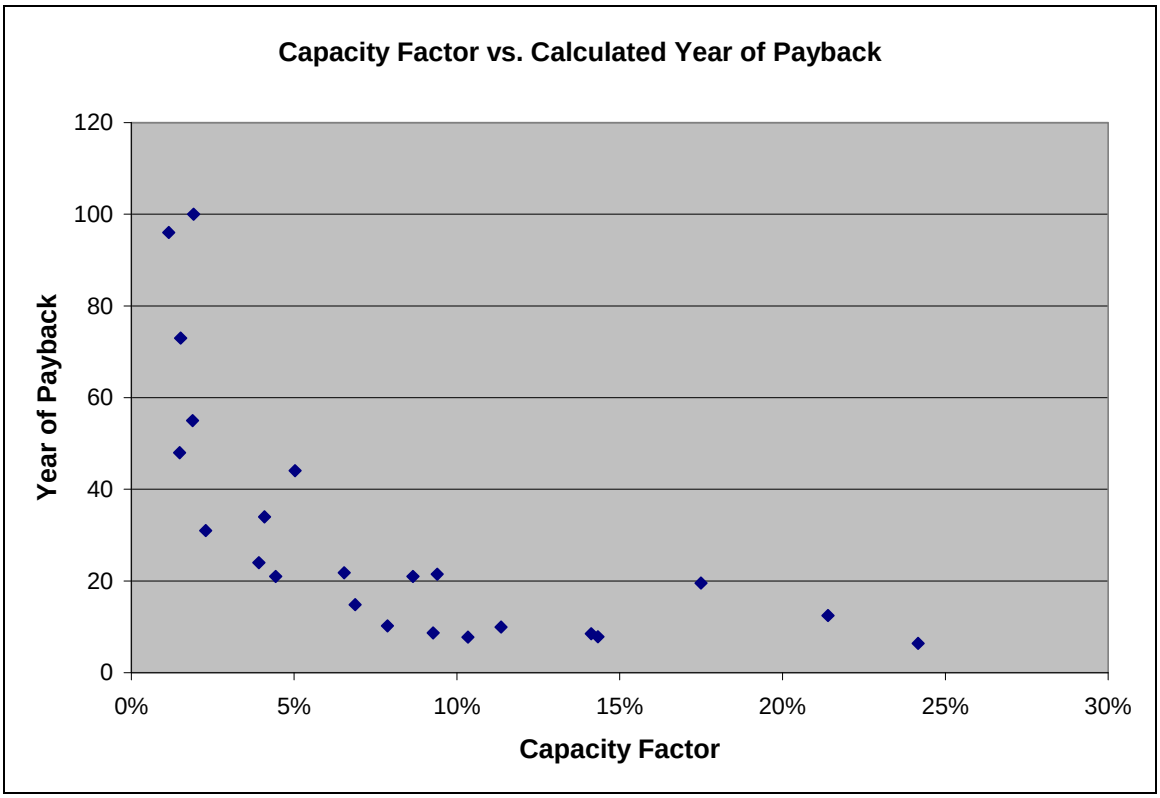
Table 6-4 Payback Estimate Statistics

Payback Estimate Statistics	
Survey Summary - All Respondents	
Calculated Payback Range	6 - 100 years
Average Calculated Payback	30.3 years
Median Calculated Payback	21 years
Per Respondent Statistics: 3 Payback Estimates	
Range of Standard Deviations	0 - 67.2 years
Average Standard Deviation	7.0 years
Average Range of Payback Estimates per Respondent	10.6 years
Samples with Range above 10 years	23 (19%)
Samples with Standard Deviation above 10 years	17 (14%)
Of Samples that included Calculated Payback - Samples with Standard Deviation above 10	8 (47%)

Source: ERP Small Wind Customers Survey, calculations done by authors

KEMA used performance data (capacity factor) and calculated payback to investigate the relationship between performance and payback. Figure 6-8 exhibits the relationship between capacity factor and calculated payback. Note that paybacks of 20 years or less were achieved only by systems with capacity factors of at least 7 percent. Some systems with capacity factors up to 9 percent still did not achieve a payback of 20 years or less.

Figure 6-8: Capacity Factor and Year of Payback



Source: ERP Small Wind Customers Survey, calculations done by authors

Figure 6-9 represents the same information as presented in Figure 6-8, except that the simple rate of return is substituted for the year of payback, where:

$$\text{Simple Rate of Return} = \frac{1}{\text{Year of Simple Payback}} \qquad (2)$$

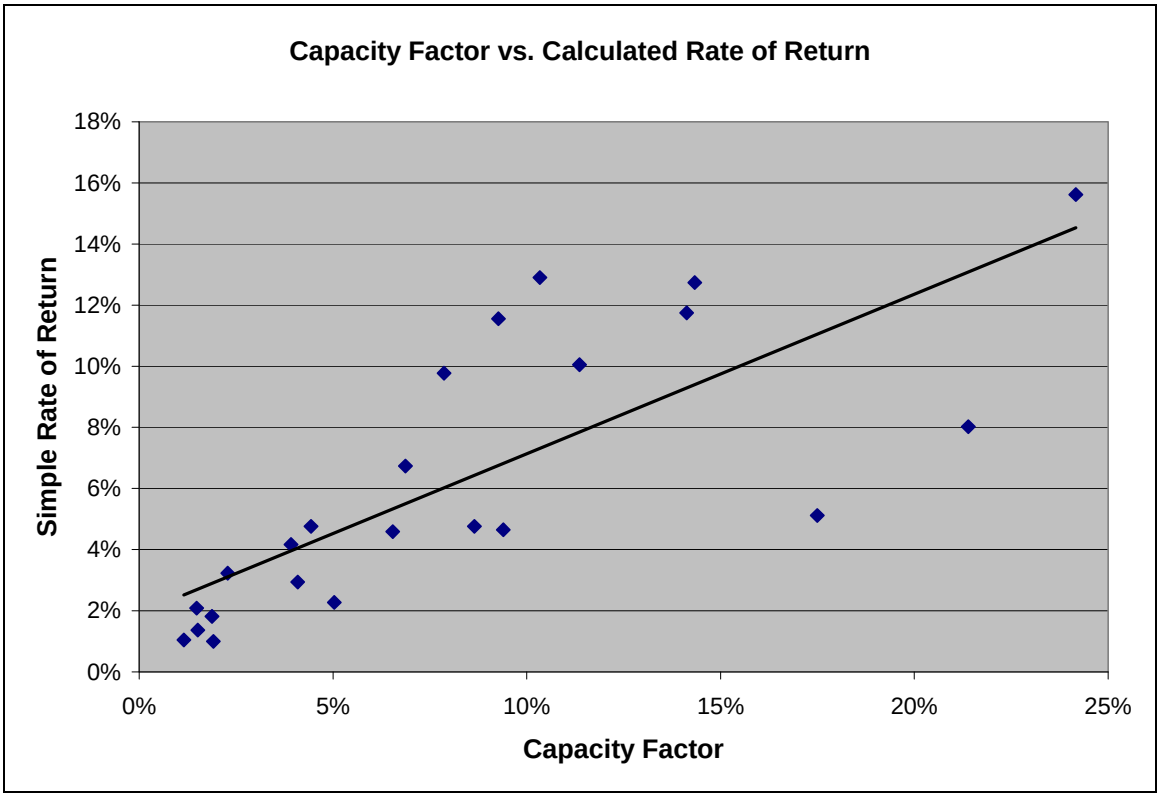
Since the capacity factor is directly proportional to kWh production, which, in turn, is directly proportional to revenue, the capacity factor should have a generally linear relationship to the simple rate of return. Figure 6-9 reflects the broad range of simple rate of return given variation in turbine pricing between model, year, and location as well as the savings associated with non-kWh revenue or benefits. This data reflects capacity factor and rate of return for all data collected in the survey from 1999 to present. This collection of data includes variation in upfront costs, offset energy rate, varying incentives, and, in some cases, different technologies. It also includes all wind turbine capacities and varying hub heights. The general trend is however clear—increased capacity factor is associated with an increase in the simple rate of return. The linear trend line in Figure 6-9 resulted in a R^2 value of 0.586 and a linear relationship of:

$$\text{Simple Rate of Return} = 0.522(\text{Capacity Factor}) + 0.0191 \qquad (3)$$

The R^2 value suggests that the relationship, although following a clear trend, does have some inherent error between the trend line and the values, though these errors lie both above and

below the trend line. The collection of values in the lower left-hand corner of the chart represents the systems with poor performance and poor payback.

Figure 6-9: Capacity Factor and Calculated Simple Rate of Return



Source: ERP Small Wind Customers Survey, calculations done by authors

Small Wind Payback With the ITC

The recent adoption of the long-term federal Investment Tax Credit and the associated removal of the $4000 cap for small wind systems starting in 2009 will have a significant impact on the adoption of small-wind systems. KEMA used its *pro forma* Small Wind Financial Modeling Tool to estimate payback of a typical small wind system in California. The analysis used current ERP rebate levels as well as the uncapped ITC incentives with the intention of providing an understanding of approximate paybacks going forward.

Independent of the ERP rebate amount, the primary financial drivers of payback are installed cost, offset electricity price, electricity price escalation rate, and discount rate. For any given system, the capacity factor is the primary determinant of system performance. KEMA's main assumptions are presented in Table 6-5.

Table 6-5: Small Wind Financial Assumptions

Major Financial Assumptions	
System Cost (0 kW - 3 kW) [$/kW]	$ 7,500
System Cost (10 kW) [$/kW]	$ 5,000
Off-set Electrical Price [$/kWh]	$ 0.200
Annual Electricity Escalation Rate	2.0%
Discount Rate	5.0%
System Lifespan [years]	20

Source: Authors

The installed system cost assumptions were based on reported system costs. As was discussed in the system cost analysis section, two clear price trends were seen: $7,500 per kW for systems under 3 kW and approximately $5,000 per kW for 9 kW to 10 kW systems. Both costs were modeled for the appropriate turbine size. The offset electric price assumption of $0.20 per kWh is slightly higher than the average electricity price across the state and is intended to reflect the assumed tendency that small-wind system owners reside in larger homes using more electricity and thus pay at a higher rate tier. The annual electricity escalation rate of 2 percent is meant to reflect a conservative escalation of electricity price over the long term and is generally in line with estimates from the U.S. Energy Information Administration (EIA). Since many small wind owners in California pay cash for their system, the discount rate is intended to reflect the declining value of that money on an annual basis. This value includes both inflation and the value of a low-yield alternative investment. The system lifespan of 20 years is intended to reflect a conservative industry standard.

KEMA analyzed the payback of small wind systems for a variety of capacity factors. The analysis focused on two rebate values: systems under 7.5 kW and a 10 kW system. The 10 kW system was chosen because this is the predominant system size above 7.5 kW. The capacity factors analyzed include the average capacity factors of systems reported (11 percent) and one standard deviation above and below the population mean capacity factor: 4 percent and 18 percent. The calculated paybacks include the uncapped federal ITC, which provides a major benefit to the economics of small wind systems. The paybacks are presented for smaller wind systems less than 3 kW in Table 6-6 and for a 10 kW system in Table 6-7.

Table 6-6: Predicted Payback of Small Wind Systems (0 kW to 3 kW), Including Federal ITC

Expected Capacity Factor	Simple Payback [years]	Discount Payback [years]
4.0%	Never	Never
8.0%	16.7	Never
11.0%	12.7	19.8
14.0%	10.2	14.4
18.0%	8.1	10.6

Source: Authors' calculations

Table 6-7: Predicted Payback of Small Wind Systems (10 kW), Including Federal ITC

Expected Capacity Factor	Simple Payback [years]	Discount Payback [years]
4.0%	15.4	Never
8.0%	8.3	10.9
11.0%	6.2	7.5
14.0%	4.9	5.7
18.0%	3.9	4.3

Source: Authors' calculations

There is a clear trend in payback: The larger systems provide a better payback for a given capacity factor than the smaller systems. Although the rebate is somewhat reduced (from $2.50 per watt to $2.25 per watt for a 10 kW system), the decrease in the installed costs more than make up for the difference in rebate. In practice, the larger systems can often justify a higher turbine height; and therefore, these systems will achieve higher performance than smaller systems. However, the upfront costs of a larger, 10 kW, system might make the higher performance attributes out of financial grasp to some.

KEMA compared ongoing paybacks of small wind systems to the paybacks of residential photovoltaic systems. The paybacks of residential photovoltaic systems were calculated using KEMA's *pro forma* PV Financial Modeling Tool. KEMA used similar electricity prices, electricity escalators, and discount rates that were used for small wind systems. However, the installed system cost was assumed to be $9,000/kW, reflecting installer estimates of installation costs; and also, assumed system lifespan to be 25 years. These assumptions are summarized in Table 6-8.

Table 6-8: Residential Photovoltaics Financial Assumptions

Major Financial Assumptions	
System Cost [$/kW]	$ 9,000
Off-set Electrical Price [$/kWh]	$ 0.200
Annual Electricity Escalation Rate	2.0%
Discount Rate	5.0%
System Lifespan [years]	25

Source: Authors

Capacity factors for photovoltaic systems in California, based on an AC system capacity, can ideally be as high as 19 percent. Systems in less sunny areas or systems installed to non-ideal orientations and tilts can have capacity factors around 14 percent. KEMA assumed an ongoing California installation rebate at Step 4, which is $1.55 per watt. The paybacks of residential photovoltaic systems for capacity factors between 14 percent and 18 percent are given in Table 6-9. The payback periods are in the same general range: from 13 years to just over 16 years. The solar systems show significantly less fluctuation in capacity factor and, therefore, less range of system payback. For net-metered photovoltaics systems that do not provide 100 percent of the participant's electricity needs, there is some additional benefit as photovoltaics consistently produce electricity during peak periods. This can benefit the customer if they pay time-of-use or peak/off-peak rates, and it can benefit the electrical grid by reducing peak load. Although small wind systems follow seasonal and daily trends, they do not consistently produce the bulk of their electricity during peak hours.

Table 6-9: Predicted Payback of Residential PV Systems

Expected Capacity Factor	Simple Payback [years]	Discount Payback [years]
14.0%	16.5	Never
15.0%	15.6	Never
16.0%	14.7	Never
17.0%	14.0	23.2
18.0%	13.3	21.4

Source: Authors' calculations

The residential photovoltaic systems present similar average payback to small wind systems under 3 kW. The 10 kW wind systems appear to have a better payback for most capacity factors than the residential photovoltaics. The discounted payback is significantly longer than the simple payback for photovoltaic systems, as the longer payback period results in additional compiled discounting. When compared to the average small wind system discounted payback, this discrepancy between simple and discounted payback is much larger for photovoltaics, as

the average small wind system payback is generally shorter than photovoltaics. The long discounted payback term of photovoltaics makes them less attractive from an investment standpoint than the typical wind systems. Of special note is that, for a given installed kW of system capacity, a photovoltaic system will produce approximately 45 percent more energy than the average wind system. This should be considered in the context that a photovoltaic system is approximately 20 percent more expensive per installed kW for wind systems under 3 kW and approximately 80 percent more expensive per installed kW for a 10 kW wind system.

ERP Rebate

The economic feasibility of these small wind systems depends, at least in part, on the rebate provided through the ERP. To gauge the importance of this rebate, survey respondents were asked how important the rebate was to the purchasing of their system. As shown in Table 6-10, respondents stated overwhelmingly that the rebate was either very important or essential to their purchasing the system. Only 4 percent of the respondents said that it was only somewhat important and no respondents mentioned that it was not important at all. The results clearly show the dependence of emerging small wind systems on the incentives provided through the ERP.

Table 6-10: Importance of Rebate

Importance of rebate in purchase decision		
Essential	83	70%
Very important	30	25%
Somewhat important	5	4%
Not important at all	0	0%

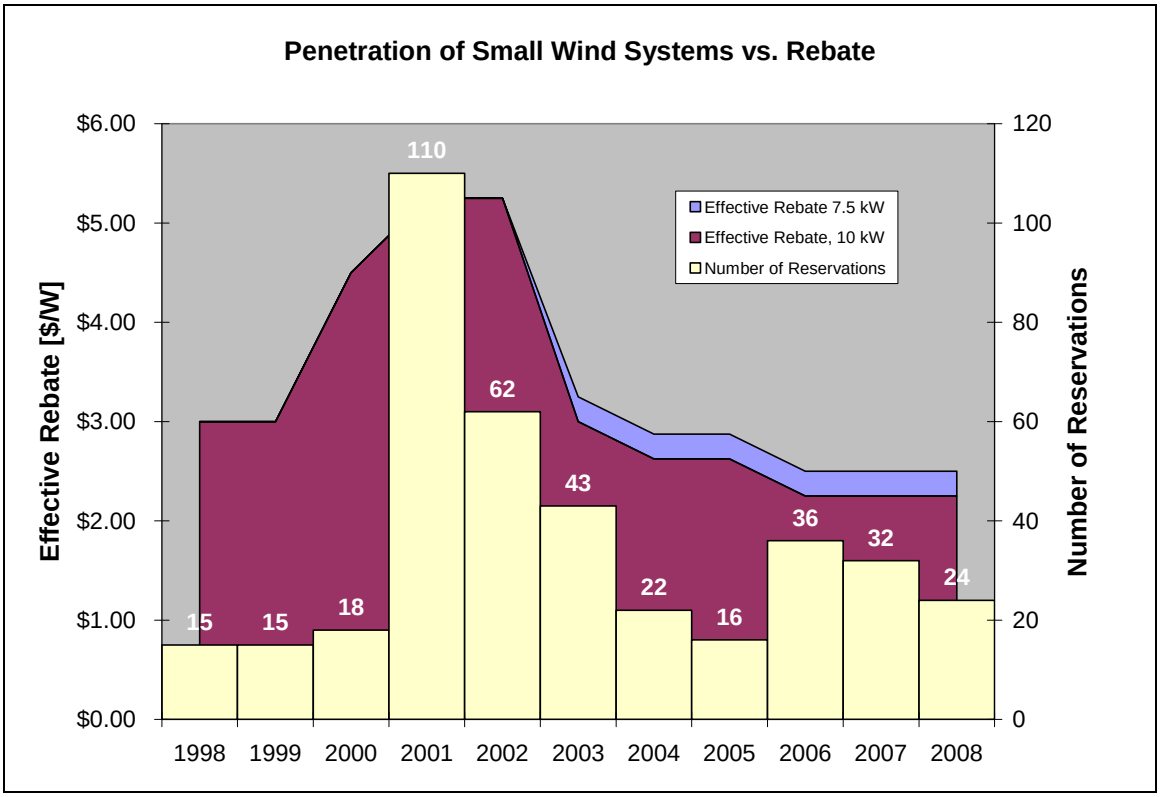
Source: ERP Small Wind Customers Survey

Using program data, KEMA analyzed the penetration of small wind systems since 1998. This was done with the intention of quantifying the dependence of installation numbers on the rebate level. Over the period analyzed, the rebates provided through the ERP varied and included both upfront installation incentives as well as tax credits.

For each year in question, KEMA calculated effective rebates for systems in dollars per watt. This effective rebate included the rebate amount as well as the tax incentive for available years. KEMA based the value of the tax incentive on an approximate installed cost of $5 per watt. Because for certain years, per-watt incentives were reduced for systems above 7.5 kW, KEMA calculated an effective rebate for systems up to 7.5 kW and also for a system representative of 10 kW. Figure 6-10 presents incentive levels from 1998 through 2008 against the number of projects completed for each year. The figure clearly shows the large range of installations for different years, ranging from 15 installations in the first year to 110 installations in the fourth year and back down to 16 installations in the eighth year. In 2008, only 24 systems were reserved. Of special note is that small wind system installations in California have not seen the exponential

growth that emerging technologies generally follow. This can be due to outside limiting factors such as permitting, additional property tax costs, and uncertainty about performance. Also, this can be a result of competing technologies, such as solar photovoltaic systems, which enjoy higher predictability and competitive rebate amounts. Also, only a fraction of California residences and commercial properties are appropriate for the installation of small wind systems. A site must not only be located in a windy part of the state, but also have sufficient open land area free of obstacles. These requirements for siting are much more stringent than for photovoltaics, where a much larger portion of the population has the appropriate location to site a system.

Figure 6-10: Small Wind Systems in California vs. Rebate



Source: ERP Database

There is a partial dependence of reservations booked related to the effective rebate amount. When the small wind rebates spiked in 2000 and 2001, the greatest number of systems was installed. As the rebate dropped off after 2003, installations declined significantly. The number of installations, of course, does not depend solely on the ERP rebate amount. Additional federal rebates are available at different times, and manufacturer and installer prices fluctuate over time. Furthermore, some residents might have decided to move forward with a small wind system in reaction to the 2000/2001 California energy crisis with the intention of becoming more self-sufficient and stemming future blackouts. The proper infrastructure must also exist to support the manufacturing and installation of these wind turbines. This infrastructure will often take one or two years to ramp up to meet current demands. Like most markets, the small wind market often follows the concept of supply and demand: When demand is high and few

manufacturers and turbines exist, costs increase. When demand drops and the turbines and installers remain in the market, costs are lowered to compete for business.

The penetration curve of the small wind rebate is shown in Figure 6-11. There is a general trend that shows that installations will increase with rebate amount. Although this relationship is not truly linear, the 11 years were fitted to a linear trend line to attempt to quantify this relationship. The data shows a significant spread, with the R^2 value of 0.4896. This is reflected in some of the outlying points especially in 2000 when rebates were high but installations remained low. This is possibly a result of insufficient program awareness or a lack of qualified installers for that year early on in the program. The data follows a general trend line of:

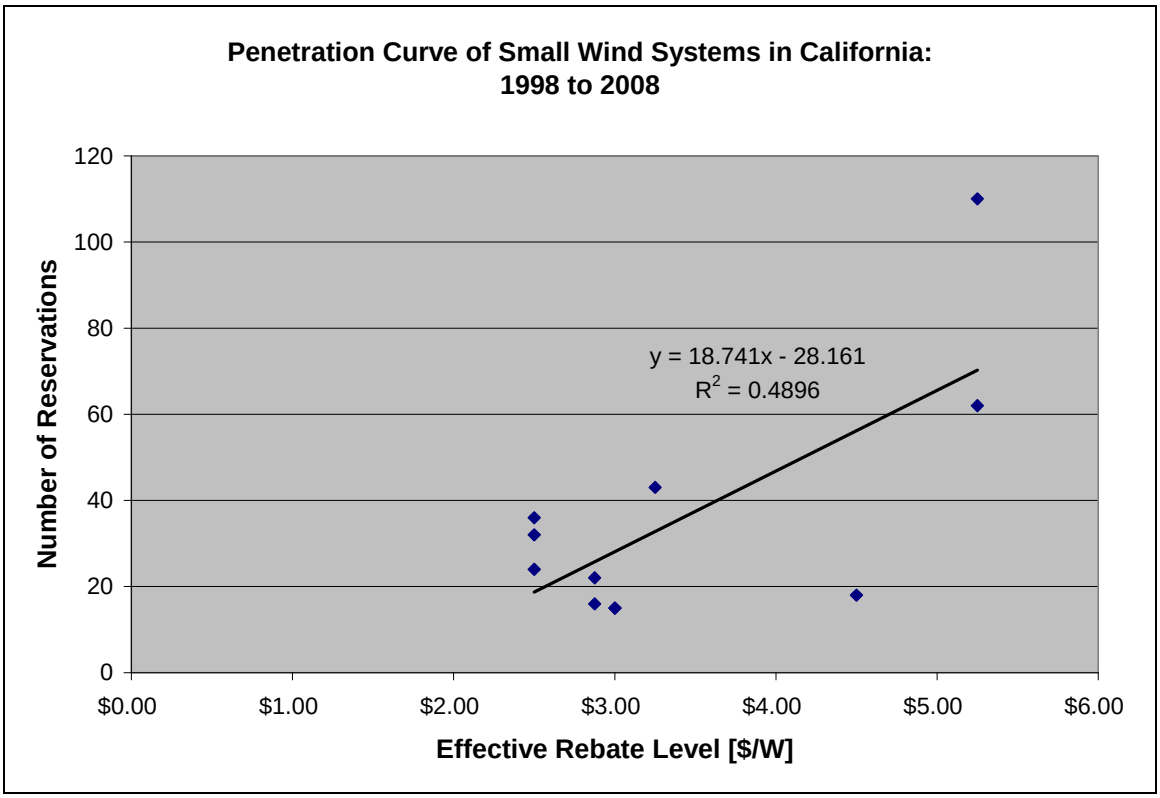
$$\text{Number of Reservations} = 18.74(\text{Rebate in \$/W}) - 28.16 \qquad (4)$$

The information can also be looked at using an exponential relationship between rebate and installation number, which better reflects the true nature of the relationship:

$$\text{Number of Reservations} = 8.30\exp^{0.366(\text{Rebate in \$/W})} \qquad (5)$$

These relationships contain significant uncertainties and should be used only for a qualitative understanding of how reservation numbers depend on rebates. As mentioned earlier, many other factors apply to system adoption, including federal incentives, existing infrastructure, pricing, and competing technologies.

Figure 6-11: Penetration Curve for Small Wind Rebate



Source: ERP Database, calculations done by authors

The penetration and adoption of emerging technologies should be looked at in a separate category from widespread adoption. Under conditions for widespread adoption, an existing rebate (or no rebate at all) would be kept constant, and the penetration of the technology would grow exponentially among early adopters as awareness and confidence in the technology spread. Therefore, the above analysis pertains to a very early market penetration where the infrastructure is generally held steady and does not expand rapidly.

Because rebate amounts, incentives, and costs are currently fluctuating, the progress toward acceptance of a technology like small wind systems is difficult to pin down. The interest in the systems depends in part on the incentive level, so technology acceptance is not steadily increasing over time, but rather dependent on the fluctuating rebate, outside incentives, and electricity prices. The acceptance of a technology into the market over time will generally increase as people slowly become more accustomed to the existence of the technology, as long as there are no significant negative outside influences. Because of the large fluctuations in outside factors, the early market penetration of small wind systems has fluctuated year by year, as is seen the actual annual documented installations.

CHAPTER 7: Recommendations

The goal of the ERP is to accelerate the development of the wind market and to remove as many barriers for the industry as possible. Although it is not within the Energy Commission's power to correct every market barrier, there are some improvements that can be made to the ERP. In the paragraphs below, KEMA describes the market barriers and provides recommendations ranked by their urgency, importance, and effort of implementation. An urgency level of "immediate" means the recommendation should be implemented as soon as possible, "medium-term" means it should be implemented within three years, and "long-term" means it could be implemented in the years beyond. The level of importance indicates how disruptive the barrier is if the recommendation is not implemented. The importance level of "high" means that the recommendation could present a hindrance to market development, whereas an importance level of "low" means that the recommendation is nice to have but not necessary for developing the market. The effort of implementation indicates the level of effort (human resource and funds) the Energy Commission requires to effect the recommended change. These recommendations are listed in order of their urgency and importance.

Turbine Certification

The two main issues with wind turbine certification are ensuring product quality (including product reliability and safety) and performance. Currently, there are no requirements in the *ERP Guidebook* to verify performance claims from wind turbine manufacturers. When a manufacturer applies for ERP listing, they will submit either certification to an appropriate wind turbine standard (such as IEC 61400-2) or 12 consecutive months of output (kWh) data in a 12 mph or better wind site. The 12 consecutive months of output data is self-reported by the manufacturer with no requirement for third-party verification.

Performance Certification

KEMA recommends that the Energy Commission include, as an eligibility requirement, certification to IEC 61400-12-1 "Power performance measurements of electricity producing wind turbines" by a qualified third party. This standard provides a uniform method that will ensure consistency and accuracy in the measurement and analysis of power performance by wind turbine generator systems. One of the main results of applying this standard is generation of a performance curve. The Energy Commission should consult third-party testing facilities before implementing this change and determining a compliance date for the manufacturers.

The current eligibility requirements of either 1) certification to an applicable wind turbine standard (such as IEC 61400-2) or 2) 12 consecutive months of output data; would remain in effect until another certification standard that addresses product quality, durability and safety can be developed and adopted.

Urgency Level	Immediate
Importance	High
Effort	Low

Safety, Quality, and Durability Certification

In the short term, a more comprehensive certification protocol should be implemented to account for a products' overall quality (including durability and safety), instead of simply performance. AWEA has developed a standard (AWEA 9.1 – 2009) for this purpose with the intent to have products certified by the Small Wind Certification Council (SWCC). This standard includes the following provisions:

- Performance testing.
- Acoustic sound testing.
- Strength and safety of the turbine system.
- Duration testing.

There are no provisions in the AWEA standard that directly address electrical safety of the generator system. The current option of 12 months of output data (kWh) at a 12 mph or better annual wind speed site was originally adopted as a method to demonstrate product quality and safety. Should the AWEA standard be adopted, a "12 months of output data" requirement would be unnecessary; therefore, it is recommended the Commission discontinue this option.

The AWEA standard is intended to ensure the quality of wind turbine products can be assessed while imposing only reasonable costs and difficulty. The terms "reasonable cost and difficulty" are used in the standard and are the judgment of the committee members involved in the development of the standard. One complaint of certification to IEC 61400-2 is that many of the requirements are derived from large, utility-scale-type wind turbines, although it is titled "Design requirements for *small* wind turbines." Specific departures between the AWEA and IEC standards are provided to account for technical differences between large and small wind turbines.

Should AWEA 9.1 – 2009 be adopted, certification to IEC 61400-2 would not be necessary for the types of turbines eligible for the ERP (less than 30 kW). Also provisions are included in the AWEA standard for developing performance curves; so a separate performance certification to IEC 61400-12-1 would not be necessary.

AWEA 9.1 – 2009 does not include provisions for directly certifying the electrical safety of the generator. Currently, there are two UL standards that cover generator system safety requirements:

1. UL 1004-1-"Rotating Electrical Machines – General Requirements"

This standard covers a number of topics such as electrical grounding, electrical insulation, environments, and so forth. A full table of contents can be viewed on UL's website.[32]

2. UL 1004-4-"Electric Generators."

   This standard is applied on conjunction with UL 1004-1 and includes performance scenarios such as overspeed, short circuits and electrical surges.[33]

It is recommended that certification of the wind turbine generator to these safety standards also be adopted.

It is uncertain what the costs will be for product certification to AWEA 9.1 – 2009 or to UL 1004-1 and UL 1004-4. Any changes to ERP equipment certification protocols must consider the additional cost burden on equipment manufacturers as it relates to incentive rates that will be provided. In addition, sufficient time must be given to the manufacturers to recertify their products to a new standard.

Urgency Level	Medium-term
Importance	High
Effort	Low

Inverter Certification

Some wind turbine products have integrated inverters that report power output as a complete system. In such cases, the maximum continuous power output and conversion efficiency tests for the inverter (currently required for the ERP) give very little or no useful information. Performing these tests places undue cost on the manufacturer.

In other cases where the system has a separate inverter, the required conversion efficiency test may not be very representative of a wind turbines' load profile. The load profile defined in the conversion efficiency test is more suitable for PV systems. Also some inverters on the ERP eligibility listing may only be suitable for PV systems and should not be used for wind turbines.

The following changes to inverter eligibility requirements and inverter listings are recommended for wind turbine systems (the same recommendations apply to fuel cell systems):

1. Remove the requirement for the conversion efficiency test as currently defined in the *ERP Guidebook*.

[32] http://ulstandardsinfonet.ul.com/tocs/tocs.asp?doc=s&fn=1004-1.toc
[33] http://ulstandardsinfonet.ul.com/tocs/tocs.asp?doc=s&fn=1004-4.toc

a. For systems with an inverter integral to the wind turbine generator (or fuel cell generator) where the rated output includes both generator and inverter, no conversion efficiency test should be required.

b. For separate inverters to be used with wind turbine generators (or fuel cell generators) only, use the conversion efficiency at peak output power; therefore, no weighted efficiency will be calculated. This method would provide comparable ratings for systems with and without integral inverters.

2. Remove the requirement for the maximum continuous output power test for wind turbine generators (or fuel cell generators) with integral inverters. This test requirement would remain in place for separate inverters to be used with wind turbines.

3. Develop a new equipment listing with inverters applicable to wind turbine and fuel cell systems. This will eliminate all inverters that are applicable only to PV systems.

Urgency Level	Medium-term
Importance	Medium
Effort	Low

Production Estimation Tools

Production estimation tools can offer several advantages, and some disadvantages, to the development of small wind systems. A production estimation tool is essentially an on-line, publicly available calculator that uses site specific information to predict system performance. A typical estimation tool will use:

- Wind data (either from a wind map or a data collection site)
- Wind system specifications (that is, rated power, hub height, power curve, and so forth)
- Site data (location, elevation, surrounding land cover, and so forth).

A tool is typically intended to be used by experienced contractors, consultants, and trained project owners. As an output, an estimation tool could provide annual energy production, average wind speeds, wind speed distributions, and potentially estimate uncertainty and economic payback.

Estimation tools can help contractors and project owners make energy production estimates, sometimes better than would be calculated through other methods. Some contractors provide sub-par resource estimates through the use of non-standard or back-of-the-envelope estimation techniques. An estimation tool can offer a quantitative method for estimating annual energy output when the user is properly trained.

On the other hand, an improperly used estimation tool can provide a seemingly precise estimate of annual energy production, though the value could be largely inaccurate when compared to actual production. Therefore, the tool can artificially lend validity to an inaccurate resource assessment. Estimation tools also require input on wind conditions, typically from wind maps. Without accurate wind maps, the estimation tool can provide an inaccurate estimate.

The Commonwealth of Massachusetts, through the Massachusetts Renewable Energy Trust developed a Small Wind Energy Estimator Tool (SWEET)[34] with the intent of improving the production estimates for small wind systems in the state. The tool is openly available for use by the public. Though the tool has only been in operation since April 2008, it was tested on a collection of existing small wind systems. For these systems and used under expert guidance, the tool was found to predict annual energy output within 10 percent of actual energy output for a set of installations. The tool is designed for use by experienced contractors or consultants. The Commonwealth is considering providing training to contractors interested in learning to use the tool.

KEMA recommends that the ERP require or suggest the use of a production estimation tool for the planning of small wind systems. Furthermore, the ERP should consider providing seminars to educate contractors on its proper use. The ERP could potentially use pre-existing, publicly available estimation tools or decide to develop one of their own. The use of a production estimation tool, along with improved wind maps, installer siting training, and estimator training, should work to dramatically decrease the uncertainty of estimated energy production numbers. The result should be fewer underproducing systems, greater satisfaction with the program, and overall better payback for the systems.

Urgency	Medium-term
Importance	High
Effort	Intermediate

Wind Maps for Small Wind

Small wind projects usually do not have the time and budget to collect wind resource data on site for a full year; therefore, they resort to publicly available wind maps as their primary source of assessing wind resources. Although NREL and the Energy Commission have published wind maps for California, these maps are mostly designed for utility-scale wind projects. The only applicable map currently available is the Energy Commission's wind resource map measured at 30 meters above ground, which is deemed too high for some projects.

[34] The SWEET is available at http://www.masstech.org/renewableenergy/small_renewables.htm

In the short term, the Energy Commission should validate and improve existing wind resource data. The following measures could significantly improve California's wind resource database without exerting enormous efforts:

- Gather wind data from operating turbines with existing meteorological monitoring stations. This might require customers to self-report wind data periodically or retrofit the monitoring stations with remote communication systems to the Energy Commission.
- Install new anemometers in regions with good wind potential. This could be achieved by initiating an anemometer loan program for landowners who are interested in evaluating small wind resources in their properties[35]
- Consolidate wind resource data from other entities that already collect wind data, for example, airports and local agencies. Airports collect wind speed and direction data as low as 10 meters to ensure aviation safety during airplane landings and takeoffs; Southern California Coastal Ocean Observing System collects wind speed and directional data at 10 meters to monitor coastal conditions. Local agencies, such as San Francisco Environment's Small Wind Task Force, are monitoring wind data at 27 sites around San Francisco in order to map the city's small wind resources. The Energy Commission can enhance its wind resource database by consolidating data from these entities.

In addition, the Energy Commission should develop siting guidelines and training workshops to help wind installers better estimate wind resource availability.

Urgency Level	Medium-term
Importance	High
Effort	Intermediate

In the long term, the Energy Commission can improve on the granularity of wind resource maps by gathering meteorological data for wind resources as low as 10 meters above ground, and publishing seasonal, monthly, and daily variations by regions.

Urgency Level	Long-term
Importance	Medium
Effort	High

[35] The Energy Commission Public Interest Energy Research (PIER) Program recognized that the lack of wind data is one of the greatest obstacles to the development of wind energy at new sites. In 2005, it contracted California Wind Energy Collaborative (CWEC) to investigate how an anemometer loan program could be implemented. The CWEC report provided extensive research and recommendations; however, no action has yet been taken. The CWEC report can be found here: http://www.energy.ca.gov/2005publications/CEC-500-2005-182/CEC-500-2005-182.PDF.

Rebate Level

The ERP rebate serves multiple roles to increase the attractiveness of small wind systems to potential system owners. There is no single quantitative method for determining an ideal rebate amount; many factors must be considered. Ultimately, the determination of a rebate level is a policy decision that is more qualitative than quantitative. The Energy Commission should consider the following questions during its decision process:

- ERP rebate serves to accelerate the payback of a small wind system. What is a reasonable payback period? Should the payback period align with customers' expectations? To help answer these questions, the analysis below will describe the sensitivity of payback to ERP rebate and how small wind's payback match up with customers' expectations.

- Payback period is heavily dependent on the system's capacity factor. As shown in Chapter 6, wind capacity factors vary widely due to a multitude of factors possibly including siting, resource adequacy, installation quality, and equipment quality. Some of the performance risks can be controlled by improved ERP requirements and industry training, but others are beyond ERP's control. Should the ERP rebate adjust higher to address the unpredictability of system performance?

- The attractiveness of a small wind system is also dependent on how it compares with competing technologies, such as PV. Small wind faces a harsher public image and more difficulties in permitting, community resistance, and ambiance impacts. Should the ERP rebate adjust higher to compensate for these drawbacks?

- KEMA's cost analysis shows that there is a significant difference in costs between smaller and larger systems. Larger systems have a substantially better payback. Should ERP rebate create more parity between different system sizes?

Expected Payback Consideration

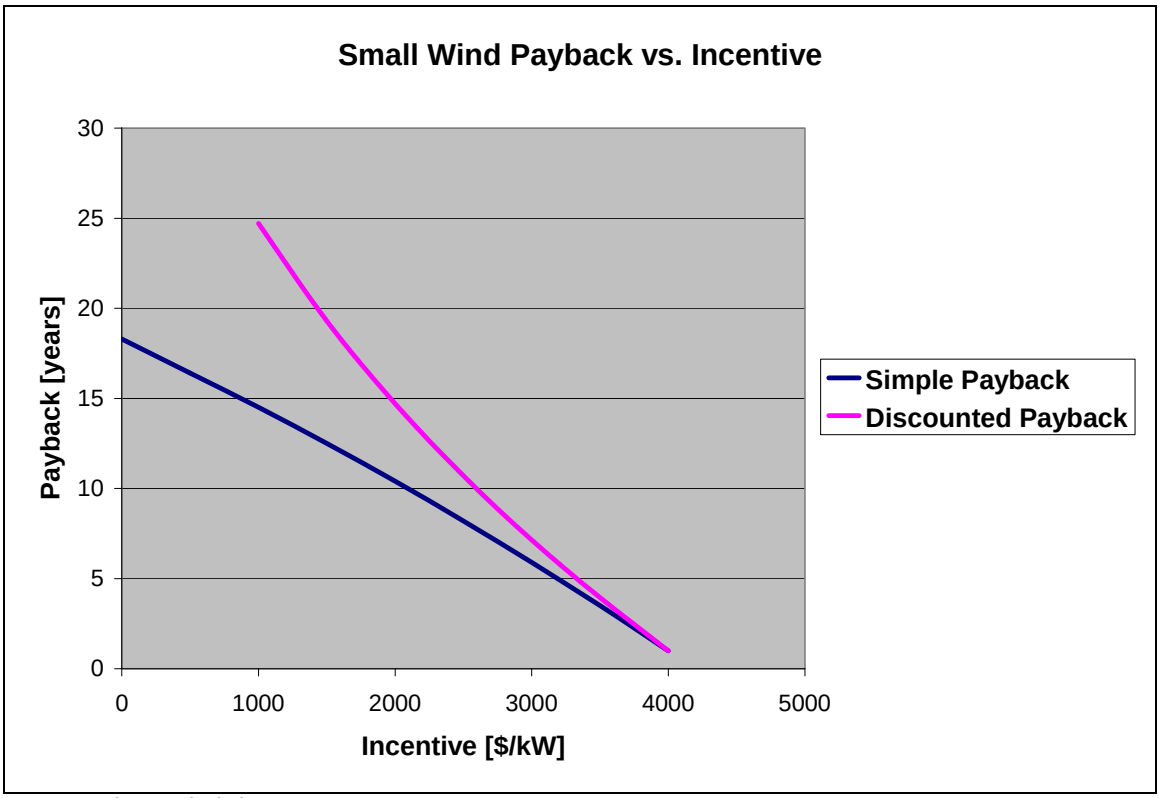
The following section will address issues the Energy Commission should consider while determining an optimal rebate level. As was addressed in the economic analysis section, the ERP rebate serves to accelerate the payback of a small wind system. A potential system owner will often view a system in relation to its potential financial payback. A system with a good payback might justify investing money that would otherwise be used in an alternative investment. The current rebate levels provide a payback heavily dependent on the system's capacity factor. Some systems result in a payback of only six years while some will never effectively pay for themselves. Respondents reported typical expected paybacks of 6–10 years, though many also expected paybacks of more than ten years.

Using its pro forma Small Wind Financial Modeling Tool, KEMA analyzed the sensitivity of small wind system payback to California incentive levels for a generic wind system. The same

assumptions were used as in the financial analysis of wind system payback for a given incentive level, except a size-independent installation cost of $6000/kW was assumed. The rebate level was varied from $0/kW to $4000/kW. The federal uncapped ITC was included in this analysis. The average capacity factor for the surveyed population (11 percent) was used.

The results of this analysis are presented in Figure 7-1. The current rebate amount of $2,500/kW (for systems less than 7.5 kW) and $2,250/kW (10 kW) lay in the middle of the incentive range. At this level, the simple payback is slightly under 10 years, and the discounted payback is 13 to 14 years. Although the discounted payback is not always presented to the potential owner, the value more closely reflects the actual benefit to the owner. With incentives of $1,500/kW or less, the discounted payback exceeds the expected life of the system, essentially meaning that the system will not pay itself back. As the incentive nears $4,000/kW, payback increases and approaches zero years.

Figure 7-1: Payback of Small Wind Systems vs. Incentive



Source: Authors' calculations

The wind industry is strongly advocating for a higher rebate level to enhance the attractiveness of small wind economics. With the adoption of the federal uncapped ITC, KEMA's analysis shows that the current ERP rebate level yields a simple payback at the low end of wind customers' expectations (6 to 10 years), and a discounted payback lower than customers' expectations. However, since a system's payback is heavily dependent its capacity factor, a system that underperforms KEMA's assumed average (11 percent) would quickly fall outside of a customer's expected payback. The Energy Commission should consider whether to increase

the rebate to better align the payback period with customers' expectations and/or increase the rebate to address the unpredictability of small wind system performance.

Small Wind Versus Solar PV Consideration

Since wind and solar photovoltaics comprise most residential renewable energy options, there is potentially some competition between the technologies. KEMA's calculated future payback estimates suggest that the average wind system to date will have a discounted payback of nearly 19.8 years for a system under 3 kW and 7.5 years for a 10 kW system (simple payback of 12.7 and 6.2 years, respectively). A typical residential solar photovoltaic system discounted payback is estimated at over 20 years, though simple payback was calculated to occur in 13.3 to 16.5 years.

Solar photovoltaics generally have greater applicability than small wind systems, as wind systems require a windy and open location while solar systems require just a sunny rooftop or open space. Though wind systems cannot be installed at most sites where solar is applicable, most sites considering a wind system could alternatively support a photovoltaic system. Many system owners have to make the decision between the two options, and the predicted payback is only a part of that decision-making process.

For a small wind system, the rebate must serve as a hedge against the uncertainty that a system owner faces. When investing a large amount of money in a small wind system, the owner faces uncertainty in:

- Energy production
- Permitting
- Lifespan and dependability
- Larger impacts (acoustic, visual, and so forth).

As was seen in the performance analysis, wind system capacity factors vary greatly, with one standard deviation of the sample's capacity factors lying between 4 percent and 18 percent. These capacity factors also do not necessarily reflect the expectations of the system owner when purchasing the system. In contrast, solar systems are highly predictable. Production is rarely 10 percent different than what was expected, and any poor performance usually results from equipment problems or rectifiable installation discrepancies. A potential renewable energy system owner will compare the risk of owning a small wind system to the reward. With a solar PV system, the risk in annual production is minimal while the reward (in the form of a payback) is only fair. With a wind system, the risk in annual production is substantial (due to the difficulty in estimating annual production) while the reward can be high (in the form of a fast payback). Without a small wind system payback better than solar PV, few potential participants will be willing to take the risk with a small wind system. The Energy Commission should consider whether to increase the small wind rebate to address the unpredictability of small wind system performance.

Size Parity Consideration

In the costs analysis section of the report, Chapter 4, KEMA portrayed the dependence of system costs on system size. A significant difference in these average costs exists between smaller systems (<3 kW) and larger systems (around 10 kW), while performance variation is not significant. In terms of payback, larger systems offer a substantial benefit. However, the larger systems require significantly more investment, which might be out of the hands of some interested parties. If the ERP is interested in bringing parity to system paybacks across the range of system sizes, it should consider adjusting the incentives accordingly. If the ERP is seeking to make larger 10 kW systems more accessible to homeowners, the rebate should be brought to match that of systems under 7.5 kW.

Conclusion

The many factors that come into play when setting a rebate should all be weighed according to the ERP's priorities. The recent adoption of the ITC and removal of its cap are significant. The ITC greatly improves the economics of a small wind project and lends a direct impact to the payback where previously only the state rebate played a role. Although some consideration should go into how the ITC will affect future ERP rebate amounts, the state should keep in mind that the Federal government adopted the ITC to drastically increase the economics of renewable energy systems. The intention of the ITC is to work on top of additional state rebates and incentives in order to help renewable technologies proliferate.

In addition to expected system payback, there are many other hurdles that small wind systems face when compared to photovoltaic systems, including uncertainty in production, permitting difficulties, property tax increases, potentially shorter lifespan, more significant acoustic impacts, and larger space use. The ERP should consider how to balance the rebate with the potential risks and benefits of a small wind system.

Because of siting constraints, the technical applicability of small wind systems across California is significantly lower than that of solar PV systems. KEMA does not expect small wind systems to compete with solar PV in terms of the number of installations. However, small wind systems are, in certain limited locations, a more cost-effective renewable energy technology than solar PV. With proper siting and installation of an appropriate and dependable wind turbine, a small wind system is expected to have a better payback than a solar PV system given the current ERP rebate levels and the newly uncapped ITC.

KEMA recommends the ERP keep its small wind rebate at current levels while allowing system owners to take advantage of the newly uncapped ITC. The ERP should focus its efforts instead on ensuring that durable small wind systems are sited appropriately to ensure consistent and sufficient performance. In coming months, the ERP should reevaluate the penetration of small wind systems resulting from the current ERP rebate level and the implementation of the uncapped ITC.

Urgency	Medium-term
Importance	High
Effort	Intermediate

Rebate Structure

Although ERP has invested in a capacity-based incentive, additional focus could be put on performance-based incentives. While a capacity-based incentive is directly related to the nameplate capacity, a performance-based incentive rewards systems based on annual energy output. A hybrid approach can also be used; a portion of the rebate is allocated based on capacity and another portion based on production. The Commonwealth of Massachusetts recently adopted a hybrid approach to improve the quality of new installations.

The benefits of full or partial performance-based incentives are that many sites with less-than-ideal wind conditions will be weeded out of the process, while sites with excellent wind conditions will be rewarded. This would effectively make windy sites even more desirable than at present. Performance-based incentives, however, also can have large consequences for an improperly sited system. System owners who, through their own neglect or through the fault of a poor contractor assessment, install a system that performs poorly will be doubly punished. The system will not only fail to produce sufficient revenue through electricity offsets, but it will also bring in a smaller rebate. This risk is most significant to unsuspecting system owners installers with insufficient training, honesty, or skill remain that do not have the wind assessment validated by a third party.

KEMA recommends that the ERP retain a fully capacity-based incentive. Since a large majority of project owners pay for their system in cash, an upfront rebate would be more valuable to customers. Unlike Massachusetts, California's small wind systems show reasonable performance; there is no need for ERP to implement a performance-based program to ensure the value of rebate expenditure. Also, a performance-based incentive would provide additional administrative and data-collection responsibilities on the ERP and would require some restructuring to implement such a policy.

Some industry stakeholders have suggested that the ERP removes the tiered rebate structure that splits rebate level at 7.5 kW. The industry argues that there is no economy of scale in small wind. However, in the KEMA costs analysis, it is shown that a significant difference in average costs exists between smaller systems (<3 kW) and larger systems (around 10 kW). The small systems averaged between $7.00 and $7.50 per watt; the larger systems averaged around $5.00 per watt. KEMA recommends that the Energy Commission maintains the current split at 7.5 kW.

Permitting Support

Permitting is one of the biggest hurdles facing small wind developments. Currently, there is no state legislation in place to guide local permitting processes. This has led to a wide range of requirements and fees from county to county. Permitting issues for small wind are well documented in the industry; organizations that have published on this topic include the Energy Commission, AWEA, CWEC, and other non-profit or academic institutions:

- *Permitting Fees and Small Wind Turbines in California Counties*, CWEC, March 2009.
- *Small Wind Permitting Challenges: Findings from a Survey of Small Wind Installers*, CWEC, March 2009.
- *How and Why to Permit for Small Wind Systems: A guide for State and Local Governments*, AWEA, September 2008.
- *Taking the Red Tape out of Green Power – How to Overcome Permitting Obstacles to Small-Scale Distributed Renewable Energy*, Network for New Energy Choices, September 2008.
- *Permitting Small Wind Turbines: A Handbook - Learning from the California Experience*, California Energy Commission, September 2003.

There is no shortage in guidelines for local agencies to follow. The main barrier to permitting is to implementing a consistent permitting process across the state. Since the Energy Commission has no jurisdiction in creating or enforcing local permitting ordinances, the only way to alleviate the permitting issue is through the state legislature. The solar PV industry is benefiting from the Solar Rights Act that limits local governments from imposing unreasonable restrictions to the installation of solar and also requires the use of ministerial or administrative application review instead of a discretionary process in solar permitting.

In 2008, the industry supported Assembly Bill 2789 that streamlines permitting process for small wind siting. The bill was modeled after existing laws for solar permitting applications. Unfortunately, the bill eventually failed at the Senate Local Government Committee in part because the legislature is not convinced that permitting is a widespread problem. As a result, the industry formed a lobbying group -- California Small Wind Coalition – in 2009 to serve as a coherent voice in an effort to convince the legislature that permitting is a widespread problem and that reform is supported by a broad coalition in the industry. Ultimately, the Coalition aims to replicate existing solar permitting laws for small wind system. The Energy Commission should actively monitor this effort and provide support as needed.

Urgency	Medium-term
Importance	High
Effort	Intermediate

Property Tax

Similarly to local permitting ordinances, the Energy Commission has no power to affect local tax levies. However, the Energy Commission should support any efforts by the industry on passing a legislation similar to Assembly Bill 1451 that exempts solar property from property tax.

Urgency	Medium-term
Importance	Medium
Effort	Intermediate

Inspection and Monitoring

The ERP has provided millions of dollars of incentives to small wind customers. It is important to periodically inspect and/or monitor these systems. The monitoring of systems can ensure ratepayers receive maximum benefits from these systems and allow the Energy Commission to identify any performance issues prevalent in the field. The Energy Commission is already required by Senate Bill 1 to conduct random solar audits across the state; it would be cost-effective for the Energy Commission to conduct wind system inspection and monitoring in conjunction with solar auditing efforts. The Energy Commission is still determining different options to conduct the mandated, random solar audits; proposed options include physical field inspection, remote system monitoring, and customer self-reporting through mail or the Internet. Any of these options would also be applicable to monitoring wind system performances. KEMA recommends that the Energy Commission conduct wind system performance monitoring in conjunction with its solar auditing program to take advantage of the synergies of these similar tasks.

To aid future performance monitoring efforts, KEMA recommends that the Energy Commission collects projected system information, such as installers' production estimates, installers' average annual wind estimates and turbine hub height, in the ERP application. In cases where wind performance fall short of customers' expectations, ERP can more easily identify which aspect of the installers' estimate is compromised. This information can help the Energy Commission target installer education and wind data collection in the future.

Urgency	Long-term
Importance	Medium
Effort	Intermediate

Installer Education and Training

To take advantage of the full ERP incentive, wind systems "must be installed by licensed California contractors in accordance with rules and regulations adopted by the State of California Contractors State Licensing Board. Installation contractors must have an active A, B, or a C-10 license." System owners can install a system themselves but are eligible for lower rebate (15 percent less). Since ERP does not require installers to have specific small wind installation experience, KEMA recommends that the Energy Commission provide workshops on site assessment, production estimation, and other installation guidelines. ERP has provided solar installer trainings in the past, and these workshops have been immensely popular and helpful. Similar trainings that cater to different experience levels should be extended to wind installers as well. Improving the quality of California's small wind work force can help build customer confidence in an emerging technology.

Currently, the North America Board of Certified Energy Practitioners is developing a set of requirements necessary to certify small wind[36] installers. Once these requirements are completed, the Energy Commission should consider whether to require ERP installers to be certified to NABCEP standards.

Urgency Level	Medium-term
Importance	High
Effort	Low

Consumer Education and Marketing

While the solar industry has enjoyed immense public recognition in recent years, small wind has not emerged from an image that is plagued with unflattering myths. These myths include bird/bats death caused by blades, interference of electrical signals, and attraction to lightning strikes. KEMA recommends that the Energy Commission increase its consumer education and marketing efforts by:

- Updating its small wind publications with current information. The Energy Commission currently publishes a consumer guide and FAQ on the ERP website. However, these publications are outdated from 2002 and 2005.
- Increasing its presence in events related to consumer energy and environment. The Energy Commission can give presentations on small wind systems, sponsor a booth, or at least distribute ERP publications at these events.
- Improving the ERP website. The consumer energy center website is the best way to communicate with potential wind customers. The current retailer/contractor database is exclusively hosted under the California Solar Initiative website where wind and solar

[36] Small wind is defined as systems under 100 kW.

contractors are indistinguishable; therefore, it is recommended that the Energy Commission separates out the subset of wind installers/retailers and list them under the ERP.

Urgency Level	Medium-term
Importance	Medium
Effort	Intermediate

Definition of Small Wind

The federal ITC defines small wind turbines as "property that generates electricity with a wind turbine that has a nameplate capacity of up to 100 kilowatts." This definition is also consistent with the definition from NREL and AWEA. The Energy Commission might consider raising the ERP cap to 100kW to be consistent with national definitions. This change would require coordination with SGIP and an adjustment in rebate structure.

Urgency	Long-term
Importance	Low
Effort	Low

Other Issues to Consider

As this study progressed, some issues emerged as potential market barriers. However due to time constraint of this project, KEMA does not have the opportunity to further investigate how prevalent these issues are in the market and whether they pose significant barriers to market development. These issues are simply listed below for further investigations:

- **Reservation period too short**. One installer wrote in a comment that the ERP reservation period is too short, especially when permitting or equipment availability cause unexpected delays. The reservation period of 12 months is designed to balance the time it takes for installers to complete a project and the time reserved-funds are allocated for projects that are not guaranteed to succeed. According to the database of completed ERP projects, the average reservation to completion time is seven months, and less than 10 percent reservations require more than 12 months to complete. Although it has not been a prevalent issue, the Energy Commission should monitor the average completion time for future projects. The Energy Commission staff should also continue its practice of liberally extending reservations for projects that have a valid excuse for delays.
- **Application process time.** Currently, ERP takes an average of 46 days to approve a reservation. There is not enough data to show whether the processing time is due to

delays at the Energy Commission or insufficient information provided by the applicant. Further investigations need to be conducted to determine measures that can be taken to improve the processing time. If the delay is at the Energy Commission, then more staff resources might be recommended; however, if the delay is at the applicant side, then perhaps the application needs to be clarified.

- **Five-year Warranty.** The California Solar Initiative requires eligible systems to carry a 10-year warranty for both labor and equipment. ERP's small wind program only requires five years. The Energy Commission could further investigate whether a 10-year warranty requirement would significantly boost customer confidence in small wind and whether it is feasible for manufacturers and installers to carry such an extended warranty.
- Warranty obligation from vendors that have gone out of business. As in the solar industry, some wind systems fall out of warranty as the installers or manufacturers go out of business. Customers need to be aware of the stability of their installer and manufacturer. There is little the Energy Commission could do but to warn the customers of this risk.
- **Full rebate level for owner-installer.** Currently, ERP discounts the incentive level by 15 percent for owner-installed systems. Some customers advocate for equal incentive for owner-installers. If the intention of the reduced incentive is to penalize the potential quality of a self-installed system, the Energy Commission should do more thorough analysis on the performance of owner-installed systems to determine whether the quality is indeed compromised.

APPENDIX A: ERP Small Wind Customer Survey

Customer Survey

Your input is important to us!

The California Energy Commission (CEC) is surveying customers who have installed small wind systems funded in part by the CEC's Emerging Renewables Program. The purpose of the survey is to better understand the current markets for these emerging renewable technologies, to accelerate the opening of these markets in California, and to improve the program.

- All of your answers will be kept strictly confidential
- Please check the responses below that most accurately represent your system
- If you do not know the answer, please leave the question blank
- Please feel free to add comments on any blank spaces on the survey

Your participation will support renewable energy research in California. If you have any questions about the survey, please contact James Lee of the California Energy Commission at (916) 653-1195.

<u>Your wind system</u>

1. Please verify the following which is from the CEC database. If your system is modified, please update the information below. If the turbine make/model is blank, would you please fill in the information for us. Thank you.

		Same?	If no, what is it?
Turbine Make	«Turbine_Make»	Yes / No	
Turbine Model #	«Turbine_Model»		
Total Installed Watt (AC)	«Size_Watts»		

2. Is your system currently operational?
   a. Yes
   b. No. Please explain. _____

Performance and Maintenance

3. How has your system been performing?
   a. Better than expected
   b. As expected
   c. Worse than expected
   d. Don't know

4. Please identify problems you had with your system, if any (please check that all apply).
   a. Mechanical
   b. Electrical
   c. Low wind
   d. Warranty issue
   e. No problem
   f. Others, please explain if any: _____

5. If you have identified any problem above, please explain how it was resolved?
   _____
   _____

6. Do you or your contractor perform maintenance on your system?
   a. Yes, I maintain the system myself
   b. Yes, a maintenance package is included from my installer
   c. Yes, I hire a contractor to maintain my system
   d. No, the system has not been maintained

7. How do you keep track of the energy production or power output of your system?
   a. Automatic performance monitoring and reporting system
   b. Regular manual readings from performance meters/inverter meters
   c. Periodical readings from performance meters/inverter meters
   d. I don't keep track of energy production

System Economics

8. Please estimate your annual electricity consumption and/or your annual electricity bill.
   a. Before wind system installation: $ (bill) _____kWh _____
   b. After: $ (bill) _____kWh _____

9. Has the electricity consumption significantly changed since the wind turbine installation? For example, change in building size, change in number of persons in building, or addition of energy efficiency upgrade etc.
   a. Yes. Please explain. _____
   b. No

10. What is the estimated annual production (kWh) from your system?
    _____ kWh

11. What is the cumulative production (kwh) from your system since the start of your system? (You can obtain this information from your meter).
    _____ kWh

Finance and Payback

12. How did you pay for your system?
    a. 100% cash
    b. Leased
    c. Financed (combination of cash and loan)

13. How long do you expect the payback of your wind system to be?
    a. Less than 5 years
    b. 6 to 10 years
    c. More than 10 years

14. How have your payback expectations changed since you purchased your system?
    a. No change
    b. Current estimate of expected payback _____# years

15. How critical was the rebate in the purchasing decision of your wind turbine?
    a. Essential
    b. Very important
    c. Somewhat important
    d. Not important at all

System and Program Satisfaction

16. Who installed your wind system?
    a. Owner installed
    b. Dealer/ contractor

17. How satisfied are you with the following?

	Very satisfied	Somewhat satisfied	Neutral	Somewhat dissatisfied	Not at all satisfied	Not Applicable
Vendor/ dealer	5	4	3	2	1	
Installer	5	4	3	2	1	
Permitting process	5	4	3	2	1	
The rebate application process	5	4	3	2	1	
Level of info provided by the CEC	5	4	3	2	1	

18. If you had the opportunity to purchase your wind system all over again, would you?
    a. Yes
    b. No
    Please explain. _____

19. Would you recommend wind generating systems to others?
    a. Yes
    b. No

20. Thank you for your participation. Can we contact you if we have questions about this survey?
    a. Yes. Phone # _____
    b. No

Please feel free to attach any performance data or reports of your wind system when you return this survey.

Additional comments:

_____

_____

_____

Thank you for taking the time to complete our survey. Please return the survey in the prepaid addressed envelope.

APPENDIX B: Small Wind Manufacturer/Installer Survey

Dealers and Installers/Trade Ally Survey

The California Energy Commission (CEC) is interested in your experiences with small wind energy systems and with the small wind rebates and assistance provided through the Emerging Renewables Program (ERP). Your answers to this survey may be used to improve the Emerging Renewables Program.

The following questions concern experiences you have had with selling or installing small wind turbines, which may have a rated capacity of **0 - 50 kW**.

Your feedback will not be directly attributed to you, so as to ensure the confidentiality of your responses.

Please have this completed and returned to CEC by January 30, 2009. Thank you.

Name	
Company	
Street Address	
City	
Telephone	
Email Address	

General Questions

1. How many years have you been in the small wind business? _____ years
   Do you have any other businesses?
   a. Yes; Type: _____
   b. No

2. What is your primary business?
   a. Manufacturer
   b. Dealer
   c. Installer

3. Approximately how many small wind turbines have you manufactured, sold, or installed in the last 12 months?
    a. Manufactured _____
    b. Sold _____
    c. Installed _____

4. What percentage of your small wind business is done in California?
    a. Last 12 months:_____ %
    b. 5 years ago: _____ %
    c. 10 years ago: _____ %

5. For California operations, approximately what percentage of your small wind sales/installations has been contingent on an ERP rebate received?
    _____ %

6. Do you forecast wind sales in California to increase in the future?
    a. Yes by _____ %
    b. Stay the same
    c. Decline by _____%

Program Effectiveness

7. On a scale of 1 to 5 where 1 is the easiest and 5 is the most difficult. How would you rate the ERP application process?

Very Difficult	Somewhat Difficult	Moderate	Somewhat Easy	Very Easy
5	4	3	2	1

Please explain:

_____

8. Have you received rebates from other sources for your California sales or installations of small wind systems (federal, utility, other state programs, etc.)?
    a. Yes
    b. No

    If yes, what are they? _____

9. How useful was ERP program assistance (website, documents, program staff) in helping your sales?
    a. Essential to completing most projects
    b. Helpful in getting projects completed
    c. Nice to have, but not essential
    d. Not very important to the completion of projects

Barriers for Small Wind

10. Approximately what percentage of proposed small wind projects in which you were involved over the last **three years** were completed and not completed?
    a. Completed _____%
    b. Not completed _____%
    c. For those not completed, reason:
    _____

11. Including capital, permitting, and installation costs. Has the cost of wind systems gone up or down in the past five years?
    a. Increased by _____%
    b. Decreased by _____%
    c. No change

12. How have the following costs changed in the past five years (please mark with an x)?

	Lower	About the Same	Higher
Hardware Cost			
Installation Cost			
Permitting Cost			
Transaction Cost			
Other Cost			

13. In your view, how has the demand and interest for small wind turbines changed over the last five years in California?
    a. Increase of _____%
    b. Decrease of _____%
    c. No change

14. Do you think that there are sufficient dealers of small wind turbines in California?
    a. Yes
    b. No

    If not, how many do you think California needs? _____

15. How would you rank the following issues in terms of how large of a barrier they are to selling a small wind turbine or bringing a small wind project to completion?

Potential Barrier	**Large barrier**	**Somewhat a barrier**	**Average barrier**	**Minor barrier**	**Not at all a barrier**
Siting (appropriate locations, public perception, etc)	5	4	3	2	1
Permitting (local)	5	4	3	2	1
Noise or Visual Issues	5	4	3	2	1
Wind Resource Adequacy	5	4	3	2	1
Electrical Interconnection	5	4	3	2	1
Cost-Effectiveness and Payback	5	4	3	2	1
Access to Appropriate Wind Turbines	5	4	3	2	1
Safety Concerns	5	4	3	2	1

16. Do you see any other barriers that may inhibit the small wind market in California?

    _____

    _____

    _____

Wind Turbine Certification

The CEC has certified small wind turbines for rebate eligibility.

17. Do you feel that the turbine certification process is fair and accurate?
    a. Yes
    b. No

    Comment: _____

18. Do you believe that CEC certified turbines are of sufficient quality and performance for small wind installations in California?
    a. Yes
    b. No

    Comment: _____

19. Have you had any significant negative experiences with CEC certified small wind turbines in the following categories?

	Negative Experiences?	
Reliability Issues	Yes	No
O&M Costs	Yes	No
Accurate Efficiency/ Power Curves	Yes	No

Permitting Questions

The following question is about your experiences with local permitting

20. Please list the major cities and counties you operate in. For each jurisdiction, please rate from 1 to 5 the relative ease of permitting, where 1 is the easiest and 5 is the most difficult.

    In addition, please also tell us the average time and cost for obtaining a permit in each jurisdiction you operate in.

County/City	Rating	Time	Cost

21. Do you have any suggestions on how the local permitting process could be improved?

_____

_____

_____

_____

Concluding Questions

22. How satisfied do you think small wind owners are with their systems?
    a. Very satisfied
    b. Somewhat satisfied
    c. Somewhat dissatisfied
    d. Very dissatisfied

23. What is your impression of the CEC's ERP website, which details small wind issues and the rebate program?
    a. Excellent
    b. Very Good
    c. Average
    d. Below Average
    e. Poor
    f. Don't Know

24. How satisfied are you with the CEC's Emerging Renewables Program and the associated rebate?
    a. Very satisfied
    b. Somewhat satisfied
    c. Somewhat dissatisfied
    d. Very dissatisfied

e. No opinion

25. Do you believe the current rebate of $2.50/watt for the first 7.5 kW and $1.50/watt for the increment above is adequate?
    a. Yes
    b. No

    Comment: _____

26. Do you have any additional comments or suggestions regarding the CEC's Emerging Renewables Program and the associated rebate?

    _____

    _____

    _____

    _____