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Making the Economic Case for Small-Scale Distributed Wind – A Screening for Distributed Generation Wind Opportunities

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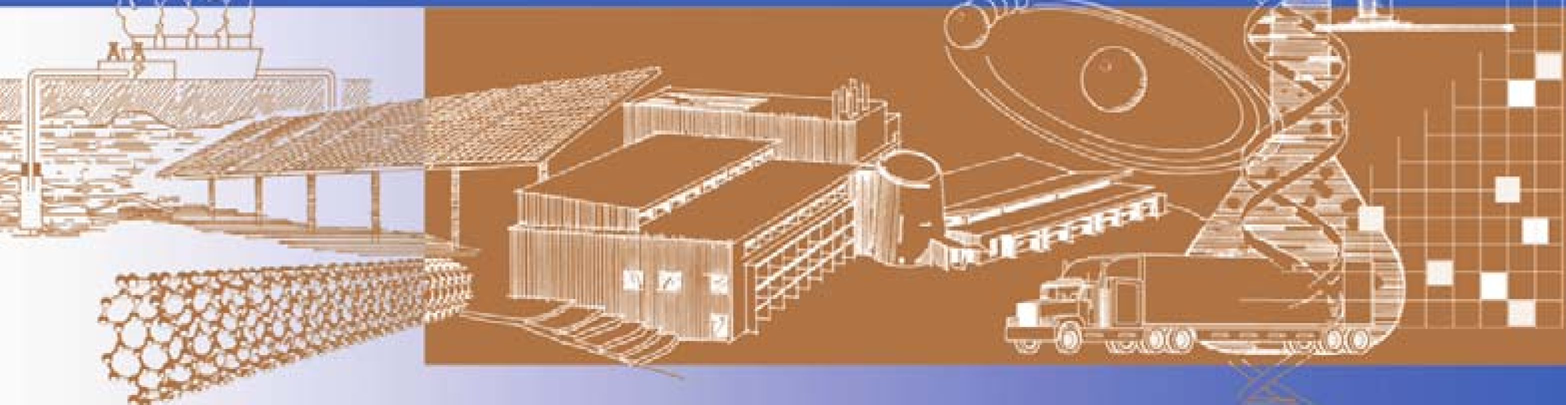

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A Screening for Distributed Generation Wind Opportunities

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1 Introduction and Rationale for Follow-up

This study was an offshoot of a previous assessment, which examined the potential for large-scale, greater than 50 MW, wind development on occupied federal agency lands. The study did not find significant commercial wind development opportunities, primarily because of poor wind resource on available and appropriately sized land areas, as well as land use or aesthetic concerns. The few sites that could accommodate a large wind farm didn't have transmission lines in optimum locations required to generate power at competitive wholesale prices.

The study did identify a promising but less common distributed generation (DG) development option. Several of the sites selected for large-scale development appeared to be promising candidates for economic, smaller-scale DG wind projects, but the screening process previously used had not been optimized to find promising DG sites.

This follow-up study documents the National Renewable Energy Laboratory (NREL)/Global Energy Concepts (GEC) team efforts to identify economic DG wind projects at a select group of occupied federal sites. It employs a screening strategy, based on project economics that go beyond quantity of windy land, to include state and utility incentives as well as the value of avoided power purchases. It attempts to account for the extra costs and difficulties associated with small projects through the use of project scenarios that are more compatible with federal facilities and existing land uses. These benefits and barriers of DG are discussed in the next section, and the screening methodology and results follow. The report concludes with generalizations about the screening method and recommendations for improvement and other potential applications for this methodology.

2 Wind DG – A Niche Market

Distributed generation wind projects offer several potential advantages over large-scale commercial wind farms, which may make them more attractive for federal sites.

- By producing power directly at the site, DG power may be valued at or near the retail price of electricity because it displaces utility-provided power.
- Some states and utilities offer incentives for small renewable power generation valued at up to 50% of system cost.
- A small project may be less likely to interfere with the multitude of land uses that are seen on federal lands, and may be easier to permit.
- On-site power generation can be integrated into the site's electrical system in ways that may reduce dependence on the utility grid and provide a measure of energy security.

These advantages over large projects must be of sufficient value to counteract the extra costs and barriers associated with small projects.

- Small projects do not enjoy economies of scale in terms of turbine pricing and availability, construction costs, and operation and maintenance (O&M) costs.

- The fixed costs associated with a wind project (permitting, engineering, legal and financial structuring expenses, crane mobilization, etc.) become a greater percentage of a small project's cost.
- The interconnection costs are higher and more uncertain because interconnection to distribution systems are governed by a variety of state and local laws and regulations.
- Utilities may oppose or impede a project if they view it as a threat.

The key elements of an economic wind project include a reasonably windy site in an area with relatively high utility rates, good financial incentives for wind technologies, and a straightforward interconnection process to lower transaction costs. The remainder of this section presents an overview of the aspects of the screening process, including turbine scenario selection and incorporation of incentives that incorporate these challenges and advantages of DG projects on federal sites.

2.1 Incentives for Wind DG

In general, wind projects are eligible for federal and state tax incentives if the owner pays taxes. If a federal DG project is structured such that a tax-paying third party owns the assets, that party can claim the accelerated depreciation and production tax credit, and either take these benefits as a form of profit or pass the benefits through to the federal agency. These incentives can be valued as high as 60% of the initial project cost, depending on the state in which the project is developed, the depreciation rate, and the value of the federal incentive.

DG wind projects can improve local grid stability and reduce the need for expensive utility infrastructure maintenance and expansion. To promote these "public goods," utilities, states, and some regional groups provide supplemental incentives to small projects. **Table 1** summarizes incentives applicable to distributed wind projects by type and scale of provider.

Table 1: Number of DG Incentives Applicable to Wind Projects by Type and Provider

Incentive Provider	Incentive Type		
	Production Tax Credits	Capital Cost Reductions	
		$/kW	% Capital Cost
Local/Utility	1	6	3
State	4	6	9
Regional	1*		1
Federal	1		
*Operates in multiple states, same incentive (TVA)			

Capital cost incentives fall into two categories: dollar per kilowatt (kW) installed or a percentage of the total capital cost for the project. The amount of these incentives is determined by the incentive provider and is based on the level of incentive required, the availability of funds, and motivation for the incentive. Dollar per kilowatt incentives are generally limited by a maximum number of kilowatts, which effectively fixes the maximum dollar limit of the incentive. Percentage of capital cost incentives are generally limited by project size or by a flat per project cap, both being fixed dollar incentive limits.

In recent years, four states – Minnesota, New Mexico, Ohio, and Tennessee – have started offering production tax credits in addition to the federal production credit. These wind production incentives offer a small payment to the project owner for each kilowatt-hour (kWh) of electricity generated at the site. They can be designed as either feed-in tariff changes or power buyback incentives, although both policy types have the same impact on potential projects as extra revenue to the owner for a certain amount of time. These state production incentives are applied in addition to the federal production tax incentive, which is applied to all potential projects, given that the financier has a sufficient tax appetite to take advantage of the incentive.

A few incentives are not included in the screening because they are too project-specific to be applied in this high-level screening. A variety of other incentives target renewable energy technology development and deployment, special financing (favorable loan terms and guarantees), property tax and sales tax reductions, and possible income through the sale of renewable energy certificates (RECs). These incentives are highly variable in their application and depend on many project-specific factors such as ownership and location. Due to the high variability of these factors, these incentives are not included in this screening. These incentives, however, should be considered for projects that show high promise through this screening – for some projects and some financing structures, these more specific incentives may have a large impact on overall project viability.

2.2 Obstacles for Wind DG

Both small- and larger-sized turbines (e.g. 10 kW – 2,000 kW) can be used in a DG project. Established small turbine manufacturers in the U.S. market are limited, and some specialize in niche markets (e.g., arctic climate). The choices for large turbines are also constrained – while many large turbines are sold in the U.S. market, most of the large-scale turbines are currently sold-out through 2007. For large-scale turbine manufacturers that have turbines available, some are not interested in DG projects or do not have the O&M network necessary to support scattered DG projects that are not typically collocated with existing large-scale wind projects. These factors will limit the options for federal sites that have sufficient load and resources to support one or more large-scale turbine.

Another challenge is the relative cost of individual and smaller-scale turbines. Costs for small-scale turbines historically are significantly higher on a dollar per kilowatt basis than for large turbines. They suffer from a lack of economies of scale in production and in purchases.

Finally, the market for large-sized wind turbines has undergone some dramatic changes in recent years associated with raw material pricing, the weakened U.S. dollar, a two-year extension of the federal production tax credit (extending it through December 2007), increased pressure on the equipment manufacturers to maintain profit margins, and speculative turbine purchasing by a number of industry participants. These factors have resulted in significant increases in the cost of turbines and towers for large-scale projects ranging from 20% to 50%. Small-scale projects have been dramatically impacted by the current wind turbine market because equipment manufacturers prefer large-volume sales – particularly over time – which results in the major manufacturers having limited interest in selling individual machines. Therefore, current market conditions are not generally conducive toward small-sized wind turbine projects. This presents a significant challenge to federal sites that want to include wind in their renewable energy portfolio in the near term.

Despite the increased cost and implementation challenges with DG wind, the available DG incentives and relative ease of siting and permitting have put it among the most cost-effective renewable DG technologies for fulfilling the federal government's Energy Policy Act[1] requirements. The following methodology attempts to identify federal sites for which the benefits of DG outweigh its extra costs.

3 Screening Methodology

3.1 Federal Agency Sites Screened

A list of federal agency sites was pulled from a federal real property database. The list was pared down to roughly 1,000 sites in all states by elimination of sites smaller than 100 acres, with the exception of those in Alaska and Hawaii. To accurately relate the sites on the U.S. Geological Survey (USGS) maps with the correct facilities, the NREL team, working with federal agency contacts, matched the master list of sites with the spatial information contained in USGS electronic maps. This process resulted in the creation of an amended list and a geographic information systems (GIS)-based database for the wind energy assessment that contained 899 facilities and more than 1,000 unique areas on the USGS map.

3.2 DG Screening Methodology

The revised screening for locating DG wind opportunities at federal facilities is based on calculating and ranking the economic benefit of a variety of DG wind scenarios at each of the 1,035 unique sites. Based on the realities of the wind DG market as described in Section 2, the scenarios were developed as a means to analyze a variety of available wind turbine sizes and configurations. The economic benefit of each scenario at each site is described in terms of its simple payback (SPB). The initial 1,035 sites were filtered for sites that had more than half a square kilometer of wind resource in Class 3 or greater, leaving 223 unique sites as candidates for DG wind screening.

3.2.1 Wind DG Project Scenarios

In response to the DG market conditions described in **Section 2**, 13 wind DG project scenarios were developed that:

- employ one to five turbines per project (for permitting ease) that can be purchased for DG applications in the next two years;

[1] Energy Policy Act of 2005: http://www1.eere.energy.gov/femp/about/legislation_epact_05.html

- are optimized to perform in either high or low wind speeds;
- are sized to fall within state incentive limitations where possible.

The turbines selected for the scenarios are presented in **Tables 2** and **3**. The turbine selections were subjective, and should not be interpreted as an endorsement of a particular model or vendor. Turbines are categorized as suitable for a low or high wind-speed site, based on the specific rating (kW/sq. m of rotor area) of the turbine models.

Table 2: Low Wind Scenarios

Scenario Identification Number	Rating	Number of Turbines	Project Size
Low Wind 1	10 kW	1	10 kW
Low Wind 2	10 kW	2	20 kW
Low Wind 3	25 kW	1	25 kW
Low Wind 4	100 kW	1	100 kW
Low Wind 5	600 kW	1	600 kW
Low Wind 6	1,000 kW	1	1,000 kW
Low Wind 7	1,000 kW	5	5,000 kW
Low Wind 8	1,650 kW	3	4,950 kW

Table 3: High Wind Scenarios

Scenario Identification Number	Rating	Number of Turbines	Project Size
High Wind 1	50/66 kW	1	50/66 kW
High Wind 2	250 kW	2	500 kW
High Wind 3	600 kW	1	600 kW
High Wind 4	1,000 kW	5	5,000 kW
High Wind 5	2,100 kW	2	4,200 kW

3.2.2 Simple Payback Calculation

In an effort to comply with the standards and methodologies most often used by federal agencies and energy service companies (ESCOs), simple payback period (SPB) was used as the determinant of project feasibility. A SPB of 10 years or less is considered feasible for this screening. By using this value, the analysis team avoids assuming values for energy escalation rates and O&M inflation factors that are required for other life-cycle cost values.

To calculate an SPB for each site, the eight low wind-speed scenarios were applied to sites with wind in Classes 3 or 4 (214 sites), and the five high wind-speed scenarios were applied to facilities with Class 5, 6, or 7 wind resource (43 sites).[2] Generally speaking,

[2] Note that 257 total sites were evaluated by the high and low scenarios. While there are 223 individual sites, 34 sites have wind resource applicable to both high and low scenarios.

the SPB is calculated by dividing the project's estimated cost (capital costs, less present value of incentives) by its estimated annual savings (value of annual power generated by project, less annual cost to operate and maintain the system). The methodology assumes that the wind resource is located in an available area at the site (i.e., land is not previously built on or too small to house the wind turbines). Land-use constraints, environmental site suitability, and cultural suitability are important site selection considerations for verifying project viability – these require additional evaluation beyond the scope of this screening assessment.

Capital Costs

Capital cost estimates were developed for each turbine listed in Section 3.2.1. These costs include the turbine, tower, transportation, balance-of-plant civil work, electrical interconnection, development costs, permitting, and contingency. The costs do not include sales taxes or financing costs. **Table 4** presents the cost estimates used for the scenarios. These costs are within +/-20%, given the uncertainty in future steel prices, exchange rates, turbine supplies, market dynamics, etc.

Table 4: Estimated Capital Costs for DG Scale Projects

Turbine	Estimated Capital Cost ($/kW)
Low Wind Scenarios 1 and 2	6,750
Low Wind Scenario 3	5,800
High Wind Scenario 1	3,500
Low Wind Scenario 4	4,000
High Wind Scenario 2	2,800
Low Wind Scenario 5	2,500
High Wind Scenario 3	2,500
High Wind Scenario 4	2,300
Low Wind Scenarios 6 and 7	2,300
Low Wind Scenario 8	2,300
High Wind Scenario 5	2,300

As detailed in **Section 2**, costs for small-scale turbines are historically significantly higher on a dollar per kilowatt basis than for large turbines. The costs presented in this table do not include any purchase credits (or buy-down programs) that may be available in some locations; however, these credits were applied in the screening as detailed below.

Incentives

Project capital cost incentives were calculated based on full application of local utility, state, and federal incentives from a March 2006 review of available incentives.[3] If an incentive was paid out over a period of time (such as a production incentive or accelerated depreciation), then the cash flows were discounted at 10% per year to obtain a present value. The present value of the incentives was subtracted from the project cost estimates to obtain the net cost of the scenario.

[3] Incentives are from the Database of State Incentives for Renewable Energy (www.dsireusa.org).

Applying the more than 40 potentially applicable incentives to 257 varied sites within 13 scenarios for wind power requires the application of assumptions regarding eligibility, applicability, and cost basis. These generalizations are aimed at increasing the number of total potential projects, rather than excluding them – it is more valuable to include a project in the screening that may not eventually make a good project than it is to exclude a project that actually becomes a good candidate. These major assumptions are:

- projects involve a third party with a tax appetite;
- state and local incentives are treated as owner's taxable income to avoid a reduction in the federal tax basis;
- projects receive maximum possible incentives for a given project size and location.

Projects involve a third party with a tax appetite.
This assumes that a federal agency will partner with tax-burdened entity to qualify for renewable tax incentives. This could happen via an energy savings performance contract, an enhanced use lease, or perhaps a utility energy savings contract. Also, the aggregation of sites will help the federal agencies attract a partner and enable them to capture some of the economies of scale that a large wind farm developer enjoys.

State and local incentives are treated as owner's taxable income to avoid a reduction in the federal tax basis.
The tax basis on which the incentive is applied has a considerable impact on the overall effect of the incentive. This point causes considerable confusion because of the shear volume of implementation rules associated with the large variety of incentives available. While the breadth of incentives offers conflicting instructions for incentive application, we can generalize the rules for incentive application from experience in the solar industry. In 2005, the Solar Energy Industries Association published a guide to applying federal incentives, which illustrated that the cost basis for applying incentives is not reduced if capital cost incentives are counted as income to the party receiving it (making it taxable income, taxed at an assumed rate of 35%). It was assumed that as long as the state and local incentives are added to the owner's taxable income, the cost basis is not reduced. It was also assumed that production incentives (federal and state) do not affect the basis for calculating other incentives.

Projects receive maximum possible incentives for the given project size and location.
If an incentive is applicable for a particular site, the screening tool assumes that it can be fully applied to the project. The projects are assumed to capture the full benefit (up to the incentive cap). The implicit assumption here is that all applicable incentives are available in all locations. There are a variety of reasons why this may not be the case, including incentives that are fully/oversubscribed or simply unfunded. Because we do not know what the state of the incentives will be when the project is started or put in service – and the tool values inclusion of projects that may be proven nonfeasible over excluding those that may be feasible – all incentives are included.

These assumptions, while necessary for the purpose of broad application to projects, create a relatively blunt instrument for estimating the value of incentives. Uncertainty related to individual project, incentive availability, and applicability leads to high variability in the actual incentive amount that is realistically available to projects. In addition, there are costs associated with structuring a project to be eligible for the incentives, and costs to collect and apply the incentives. Those costs are assumed to be a small percentage of a large DG project cost, but that is not likely to be true for a small project. The methodology does, however, select projects with the potential to gain incentives and increase their cost effectiveness. Further screening and feasibility processes will need to cull the list further based on more specific incentive availability at the time of project construction.

Project Savings Calculation

A DG wind project generates savings roughly equal to its energy output, times the cost of power for the site. Wind energy production depends on the site's wind-speed distribution and the power curve of the turbine. The NREL team assumed a Rayleigh distribution, which is a common estimating approach when only annual-average wind-speed data is available. The team created Raleigh distributions for a range of hub height wind speeds, which are based on the NREL Wind Class wind-speed ranges at 50 m. Based on the turbines chosen, representative hub heights are 30 m, 36 m, 50 m, and 80 m. Using the $1/7^{th}$ power law, equivalent wind class wind-speed ranges were calculated for the NREL Wind Classes. **Table 5** shows the equivalent average annual hub height wind-speed ranges for each wind class.

Table 5: Equivalent Annual Average Hub Height Wind Speeds (m/s) for Each Wind Class

Class	HH = 30m		HH= 36m		HH = 50m		HH = 80m	
1	0.0	5.2	0.0	5.3	0.0	5.6	0.0	6.0
2	5.2	5.9	5.3	6.1	5.6	6.4	6.0	6.8
3	5.9	6.5	6.1	6.7	6.4	7.0	6.8	7.5
4	6.5	7.0	6.7	7.2	7.0	7.5	7.5	8.0
5	7.0	7.4	7.2	7.6	7.5	8.0	8.0	8.6
6	7.4	8.2	7.6	8.4	8.0	8.8	8.6	9.4
7	8.2		8.4		8.8		9.4	
Note: The 50m hub height is the reference height.								

The power curve defines the gross power that a given turbine can produce at various wind speeds and air densities. For this analysis, and to be consistent across manufacturers, the sea level power curve was used.[4] Multiplying the wind-speed distribution for each wind class with each turbine's power curve results in the gross energy output for each turbine. GEC calculated the gross turbine energy over the range of appropriate wind classes (Class 3 and 4 for low wind-speed sites and Class 5 and greater for high wind-speed sites) to develop a linear equation describing the relationship

[4] Some manufacturers provide density corrected power curves over a range of air densities while others only provide the power curve at sea level. To reduce any bias, sea level power curves were used as the basis for the gross energy calculation.

between annual average wind speed and energy output. These equations are used in the model to calculate gross energy per turbine for an annual average wind speed within the appropriate range of wind speeds for that turbine. The gross energy per turbine is then multiplied by the number of turbines in the scenario to get the gross project energy.

Because sea level power curves formed the basis of the calculation, but most federal sites are at higher elevations, the analysis team calculated an average air density adjustment for both low wind-speed and high wind-speed sites. As air density decreases, less energy can be extracted from the wind; therefore, using sea level power curves would overestimate the energy production for most federal sites. Based on past experience, an average site elevation of approximately 650 m and temperature of 10°C was assumed, and a mid-range air density was calculated. On average, the air density correction reduces the gross energy output by 3.5 % for high wind-speed sites and 5 % for low wind-speed sites, resulting in an adjusted gross energy output.

The net turbine generation is calculated by applying energy losses to the gross turbine production. For scenarios with five turbines, the losses are assumed to be 15%. For scenarios with two to three turbines, the losses are assumed to be 12.8%. Losses for single-turbine scenarios are 11.5%. Losses include availability, transformer/line losses, control system losses, blade soiling, and wake/array losses. Availability losses account for scheduled and unscheduled maintenance, other turbine events, and collection system or grid outages. Electric losses include losses caused by the transmission distance between the turbines and the electric collection point, the on-site distribution system (for larger turbines), and transformer losses. Control system/power curve losses account for times when the automated operation of the turbine lags frequent changes in the wind speed or direction, causing the turbine to not perform exactly as predicted by the manufacturer’s power curve. Blade soiling occurs with the accumulation of dirt and insects, which affects the aerodynamics of the blades, lowering production. Wake losses refer to the lost energy production from turbines located downwind of other turbines. Although project footprints are designed to minimize waking by sufficiently spacing the turbines, wake losses still occur and a moderate wake loss value has been assumed. The impact associated with wake losses is apparent in the loss scenarios noted above, because projects with multiple turbines would incur more wake effects than single-turbine projects (where the wake losses are zero).

A low- and high-bound estimate of project output was calculated using site-specific information regarding the amount and class of wind at the site. Assumed losses as described above were also included in this calculation.

Project savings were calculated based on average energy price at the site. Where available, actual 2004 surveyed electricity prices were used, but for the majority of the sites, Powerdat data on 2004 electricity prices at the site location were used. For a very limited number of the sites (fewer than 10), for which neither of those sources provided information, the state average electricity price for electricity was used for the site.

Project O&M Costs

Operation and maintenance (O&M) costs vary significantly depending on the complexity of the turbine, the O&M strategy employed, the reliability of the equipment, site conditions, and the roles and responsibilities of the equipment manufacturer in providing service and warranty repairs (if such services are provided). O&M costs for large-scale turbines and smaller-scale versions of the large turbines generally are divided into the following categories:

- Operations (e.g., resetting wind turbines that have tripped off-line due to a fault).
- Scheduled, preventive maintenance on the wind turbines and other equipment (e.g., routine oil changes, lubrication, and overall equipment inspections).
- Unscheduled maintenance activities ranging from simple component replacements to major component repairs following a component failure.
- Periodic component overhauls and scheduled replacements (if specified by the wind turbine supplier).

The first three categories occur during the course of each year, while the fourth category occurs at periodic intervals over the life of the project. Small turbines like the Bergey would have a less rigorous O&M regime. The turbine would be inspected periodically to ensure the blades are in good condition and to grease bearings as needed. However, at the midpoint of the small turbine's operating life, a major overhaul of some components could occur. The small-turbine O&M cost shown below reflects an annualized first year cost that incorporates the low annual costs and the major overhaul.

The biggest unknowns associated with long-term recurring costs are the reliability of major wind turbine components such as gearboxes (if any), generators, and blades. This is especially true for small projects. For large projects using large turbines, the reliability and replacement costs can be estimated with reasonable certainty on an average project-wide basis. However, a small-turbine project with only slightly better or worse reliability than the fleet-wide average may result in much lower or higher costs than average. These costs are not offset by the averaging effects of a large project. This long-term recurring cost risk can be reduced some by purchasing machinery insurance.

For purposes of this evaluation, recurring O&M costs have been estimated for the first year, with an escalation rate of 3%. These O&M estimates represent an estimate of costs for operations, scheduled and unscheduled turbine maintenance, balance-of-plant O&M, and administration. The costs do not include insurance and property taxes. **Table 6** presents the annual O&M cost estimates. The costs for the larger turbines have an uncertainty of approximately +30%/-20%, while the uncertainty on the cost for the smaller turbines is approximately +/-50%.

Table 6: Annual O&M Cost Estimates

Turbine	Estimated O&M ($/turbine)
Low Wind Scenarios 1 and 2	600
Low Wind Scenario 3	1,000
High Wind Scenario 1	2,500
Low Wind Scenario 4	4,000
High Wind Scenario 2	10,000
Low Wind Scenario 5	24,000
High Wind Scenario 3	24,000
High Wind Scenario 4	42,000
Low Wind Scenarios 6 and 7	42,000
Low Wind Scenario 8	42,000
High Wind Scenario 5	42,000

Payback calculation

Combining all of the above information into the screening tool, the paybacks for individual projects within each scenario were calculated using the equation below.

$$SPB = \frac{\text{(Initial Cost – Present Value of Financial Incentives)}}{\text{(First Year Average Annual Energy Savings – First Year O\&M)}}$$

Assumptions

Besides the assumptions previously defined in this report, it was assumed that the turbines can be sited at the location where the wind is strongest at a facility (i.e., where there are no land-use conflicts, environmental concerns, cultural artifacts, or buildings at the location of the wind). It was also assumed that the facility's utility company will allow interconnection and third-party power sale to the federal site.

It is noteworthy to remember that the outputs of this screening are the result of a prescreening effort to locate the best possibilities for DG wind at federal sites, and a further, detailed study combined with site visits will help verify or refute these assumptions.

4 Results

Only 223 of the 1,035 unique federal sites had at least some (0.5 sq km or more) Class three or greater wind resource. The eight low-wind and five high-wind scenarios were evaluated for sites with appropriate resource. Sites with both high and low wind resource were evaluated under both sets of scenarios, resulting in 257 potential sites: 214 low wind-speed sites and 43 high wind-speed sites. Of the 1,927 potential projects, 655 (34%) returned paybacks of 10 years or less.

Table 7 lists the 25 shortest payback projects (ranked by conservative wind estimates), all of which were 600 kW or larger. Both high and low wind sites are shown to have low payback periods. The estimated payback is exactly that – an estimate. The assumptions made for the screening have probably resulted in optimistic payback lengths, but the overall rank order should be valid, even if more conservative assumptions were used. **Table 7** also illustrates that some sites are good candidates under multiple scenarios.

Table 7: Top 25 Potential Projects and Energy Production by Payback Period

Scenario	Site	ST	Payback Period Range(yr)		Electricity Output (kWh)	
			Low	High	Low	High
High Wind 5	Site A	AK	0.9	1	14,544,340	16,300,277
High Wind 5	Site B	AK	0.9	1	14,544,340	16,300,277
High Wind 5	Site C	AK	0.9	1	14,544,340	16,300,277
High Wind 5	Site D	AK	1	1	14,544,340	14,544,340
High Wind 2	Site D	AK	1.2	1.2	1,911,845	1,911,845
Low Wind 6	Site E	CA	0.7	1.2	2,364,307	3,203,494
High Wind 3	Site E	CA	0.8	1.2	1,664,082	2,081,114
High Wind 4	Site A	AK	1	1.2	14,918,415	16,990,179
High Wind 4	Site B	AK	1	1.2	14,918,415	16,990,179
High Wind 4	Site C	AK	1	1.2	14,918,415	16,990,179
High Wind 4	Site D	AK	1.2	1.2	14,918,415	14,918,415
High Wind 2	Site A	AK	1.2	1.4	1,702,059	1,911,845
High Wind 2	Site B	AK	1.2	1.4	1,702,059	1,911,845
High Wind 2	Site C	AK	1.2	1.4	1,702,059	1,911,845
High Wind 3	Site A	AK	1.2	1.4	1,824,479	2,081,114
High Wind 3	Site B	AK	1.2	1.4	1,824,479	2,081,114
High Wind 3	Site C	AK	1.2	1.4	1,824,479	2,081,114
High Wind 3	Site D	AK	1.4	1.4	1,824,479	1,824,479
Low Wind 8	Site F	AK	1.2	1.5	12,602,486	15,030,042
Low Wind 8	Site G	AK	1.2	1.5	12,602,486	15,030,042
High Wind 2	Site E	CA	1	1.7	1,349,131	1,911,845
Low Wind 6	Site F	AK	1.4	1.7	2,364,307	2,853,833
Low Wind 6	Site G	AK	1.4	1.7	2,364,307	2,853,833
Low Wind 6	Site H	CA	1	1.8	2,364,307	3,203,494
Low Wind 6	Site H	CA	1	1.8	2,364,307	3,203,494

Table 8 lists specific facilities that had less than a 10-year payback in multiple (more than six) scenarios. These sites appear to have a broad range of potential project sizes, and may be the best candidates for further feasibility studies.

Table 8: Facilities with Six or more Potential Project Scenarios with Less than a 10-Year Payback Period

Site	ST	Number of Potential Project Scenarios with <10-Year Simple Payback[1]	Range of Payback Period for all Scenarios (yrs)
Site H	CA	22	1.0-8.8
Site I	HI	17	4.9-9.1
Site J	MD	12	4.6-7.8
Site K	CA	12	4.8-8.9
Site L	WA	12	4.9-9.5
Site M	AK	11	4.7-75
Site N	AK	11	6.0-10
Site O	WA	11	5.3-8.3
Site E	CA	11	0.7-6.0
Site P	CA	11	1.0-9.0
Site Q	ND	11	4.4-9.9
Site R	HI	11	2.2-9.1
Site S	HI	11	2.6-9.1
Site T	HI	11	1.6-4.3
Site U	CA	11	1.0-9.0
Site V	CA	10	1.1-8.8
Site W	CA	10	1.2-10.0
Site X	NM	10	4.0-9.6
Site Y	CA	9	2.4-10.0
Site F	AK	8	1.2-9.5
Site G	AK	8	1.2-9.5
Site Z	ME	8	3.3-10

[1] Some facilities encompass multiple, distinct sites; these numbers reflect all potential project scenarios within these facilities.

5 Recommendations

The screening has identified many project opportunities that are worthy of further study. While the screening assumptions and resulting paybacks are probably optimistic (so that worthy candidates are not screened out prematurely), many of the projects would be viable at double the payback. This analysis can be enhanced with access to improved energy-rate data as well as details regarding land availability. Photo-imaging software could be used to assess land availability as a way to avoid unnecessary site visits.

Once the refined screening is complete, we recommend implementing multisite projects. By aggregating sites, the federal agencies and the private-sector development partners will capture some of the economies of scale that a large wind farm developer enjoys. A bulk turbine purchase will attract more turbine vendors and potentially improve pricing. The federal government's creditworthiness, in combination with the reduced risk of having a large number of turbines distributed over multiple sites, might induce investors to offer attractive financing rates. The costs of project structuring and collecting the federal tax incentives will be spread over a larger investment base, making the transaction more efficient.

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14. ABSTRACT *(Maximum 200 Words)*
This study was an offshoot of a previous assessment, which examined the potential for large-scale, greater than 50 MW, wind development on occupied federal agency lands. The study did not find significant commercial wind development opportunities, primarily because of poor wind resource on available and appropriately sized land areas or land use or aesthetic concerns. The few sites that could accommodate a large wind farm failed to have transmission lines in optimum locations required to generate power at competitive wholesale prices. The study did identify a promising but less common distributed generation (DG) development option. This follow-up study documents the NREL/Global Energy Concepts team efforts to identify economic DG wind projects at a select group of occupied federal sites. It employs a screening strategy based on project economics that go beyond quantity of windy land to include state and utility incentives as well as the value of avoided power purchases. It attempts to account for the extra costs and difficulties associated with small projects through the use of project scenarios that are more compatible with federal facilities and existing land uses. These benefits and barriers of DG are discussed, and the screening methodology and results are included. The report concludes with generalizations about the screening method and recommendations for improvement and other potential applications for this methodology.

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