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WIND ENERGY DEPLOYMENT IN ISOLATED ISLANDED POWER SYSTEMS: CHALLENGES & REALITIES

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Given the state of the global oil markets and the unlikelihood that islanded communities will be able to take advantage of low natural gas prices, wind development in these areas provides a strong market niche for the industry.

Introduction

Rising fuel costs, energy surety, and the carbon impacts of diesel fuel are driving remote and islanded communities dependent on diesel power generation to look for alternatives. Over the past few years, interest in using wind energy to reduce diesel fuel consumption has increased dramatically because of wind's potential economic, environmental, and security benefits to these communities. However, the task of implementing such systems has remained elusive and subject to lower-than expected performance. This poster outlines the current status of integrating higher contributions of wind technology into islanded power systems and some of the lingering technical and commercial challenges. Operating experience from a number of power systems will be described, as well as how organizations considering wind should implement development programs.

Current Markets

The market for wind-diesel technologies is expanding.

- Twenty-six projects are operating or under construction in Alaska.
- There are operating projects in almost every region of the world, representing diversity in technical and business approaches.
- Reducing diesel dependence in isolated grids is becoming an accepted option, with more interest from larger multi-lateral donor and banking organizations.
- Larger islanded communities, such as in the Pacific and Caribbean, are more interested in wind projects and now have deployment experience.
- In general, there is more interest worldwide in these projects.
- The U.S. Department of Defense is increasingly considering micro-grid applications.

Alaska Village Electric Cooperative installed three 100-kW Northern Power Systems turbines in November 2006 as part of a wind-diesel hybrid system. Two of three wind turbines can be seen in this photo over the bulk fuel tanks of the Kasigluk Power System. *Photo by Ian Baring-Gould, NREL 16097*

In Alaska:

- Approximately 134 communities have an economically viable wind potential.[1]
- Low- to medium-contribution power systems have been successfully implemented; new higher-contribution systems are beginning to be implemented.
- Alaskan communities now have experience installing and interconnecting larger wind turbines.
- The state Renewable Energy Fund helps to finance remote wind projects, providing grants to reduce the high initial cost of wind turbine installation in remote communities.
- The University of Alaska, Alaska Center for Energy and Power has conducted research and developed educational programs around wind-diesel systems.

The tower of the wind turbine installed at St. Croix Reformed Church and Kingshill School can be hydraulically raised or lowered depending on weather conditions. Photo from Don Buchanan, NREL 20816

In Canada:

- There is a potential 30 to 85 MW of wind capacity in large communities and mines with loads greater than 10 MW, with a potential diesel savings of 25 million to 120 million liters per year.[2]
- There is a potential 30 to 130 MW in smaller communities with loads less than 10 MW, with a potential diesel savings of 16 million to 77 million liters per year.[2]
- The Canadian Wind Energy association has identified 34 communities where wind energy could reduce the cost and environmental impact of a diesel-based energy supply.[3]

Recent Experience from Wind-Diesel Deployments

Deployment in Alaska and elsewhere has provided important lessons for using wind in isolated power systems. Initial findings include:

- **Projects can be expensive.** Costs as high as $17 per Watt have been reported for small (100-kW) installations with complicated or expensive foundations (including integration). Lower costs have been documented for larger or reconditioned equipment, to $4.5 per Watt.
- **Diesel plant ramp rates are important.** The importance of diesel ramping and the need for energy storage, especially in larger grids, are now better understood.
- **Many projects report poor performance compared to modeled predictions.** Many projects are reporting much lower performance than was projected using simulation models, with some projects reporting approximately 60% of predicted performance. Factors resulting in lower performance than projections include:
  - Poor resource assessment and underestimation of harsh conditions (limited data, low-measurement tower heights, icing conditions, and other climate impacts)
  - Poor system modeling, including lack of information on local performance parameters leading to faulty predictions
  - Few qualified people to implement and manage projects
  - Long contracting and deployment timelines that result in insufficient funds at the end of project implementation to allow for fine-tuning of system operation
  - Lack of ongoing technical assistance and R&D to support projects
  - Use of new, untested technologies and systems in remote communities.
- **High turbine availability can be achieved.** Some wind turbines have operated at excellent availability levels, even if plant performance was not as high as expected.
- **Lack of corporate longevity is an issue.** Many of the companies providing products and services for the wind-diesel market do not have the financial resources to address protracted technical problems.
- **Environmental regulations can limit potential project sites.** Especially in islanded communities with protected or endangered species, finding locations for turbine installations can be problematic.
- **Diesel plant advances improve low-load diesel operation.** Improvements in diesel generators and power electronics make low-load diesel operation more acceptable, reducing cost and improving control flexibility. The application of diversionary loads, even in lower-contribution power systems, is still important for proper control.
- **Expanded testing infrastructure will allow improved system development.** Expanded testing infrastructure (including the Alaska Center for Energy and Power test bed, the Energy Systems Infrastructure Facility at NREL, and the multi-megawatt isolated test facility at the National Wind Technology Center) will provide a variety of test platforms, which will allow equipment and control testing of isolated power systems and equipment from a few kilowatts to a few megawatts.

Three of six GE 1.5-MW wind turbines installed on a ridge above Kodiak, Alaska, as part of a hydro-wind-diesel power system that provides more than 95% of the community's electrical energy from renewable energy sources. *Photo by Ian Baring-Gould, NREL 29181*

The following technology advances can improve the application of smaller remote systems:

- Deployment of more advanced power control, typically in the form of secondary dispatchable loads, allows for an increased wind energy contribution.
- Expanded load-control concepts and distributed load control may allow increased wind contribution. Many are being considered by organizations such as the Chaninik Wind Group, including household electric heating using thermal stoves and electric or hybrid electric vehicles.
- Expanded use of medium- to large-scale turbines for remote applications (such as the installation of two EWT 900-kW turbines in Kotzebue, Alaska, in 2011) can improve applications for smaller, remote systems.
- Advances in software models – which expand capabilities in resource assessment, performance, control, and electrical response – have improved our understanding of wind-diesel systems.
- Expanded development of smart and microgrid concepts can spur technology innovation.
- New ownership models, including power purchase agreements, can be applicable even for smaller, isolated projects.
- Improved access to wind resource information, including new assessment techniques and easy-to-implement remote sensing technology, allow better assessment of local wind resources.
- Improved power performance and lower cost of wind and power conversion technology allow for more widespread applications.

One of three Enercon E-33, 300-kW wind turbines installed as part of the Ross Island Wind Farm, providing power to the McMurdo and Scott Antarctic Research Stations as part of a medium contribution wind-diesel power system commissioned in 2010. *Photo by Ian Baring-Gould, NREL 29393*

Implementation of Wind in Large Islanded Grids

Experiences from deployments in larger islanded grids include the following[4]:

- Developing projects through competitive power purchase agreements requires much greater engagement and oversight than conventional wind projects
- Developing power purchase agreements that include integration costs, system impacts, performance liability, and forced curtailment is much more complex than standard wind contracts. Some contracts place these liabilities on the wind supplier and others on the utility. Although both are viable, they can greatly impact performance and project economics.
- System-wide integration studies are likely needed as part of the initial project development process for any large project on an isolated grid. Companies with proven experience in islanded power systems must be employed to model system impacts if credible, real-life results are to be expected.
- The need for on site energy storage or other technologies to provide grid stability, power smoothing, and thermal unit ramp rate control must be traded against the ability of the existing power system to provide these services.
- To the extent possible, wind power forecasting should be employed.
- The interconnection of islanded communities, even through the use of undersea cable, should be seriously considered. However data on the actual performance of these systems is limited.

Lingering Industry Challenges

Many challenges continue to hamper the growth of wind technology deployment in isolated grids, including[5]:

Technical

- Tailored, unique solutions for each community leading to customized engineering, equipment, controls, and construction with little uniformity or commonality among systems
- Limited institutional track record limiting the up-take of higher-contribution power systems
- Limited common terminology or general agreement on even basic terms
- No common understanding of accurate performance metrics
- Very limited funding for technology development resulting in development being funded on the back of specific deployment projects
- Even less funding for follow-up, evaluation, impact assessment, and technology improvement
- High and undocumented installation and operation expenses

Institutional

- Poor understanding of the technology by decision makers
- Lack of trained personnel; lack of trained personnel in communities
- Potential environmental impacts, including habitat reduction, especially in isolated areas which may have unique species
- Competing use, siting, or other development concerns, typically in constrained geographic areas
- No coordinated outreach, targeted industry or users group, or expanded communications network

Policy

- High capital cost and general discounting of community sustainability
- Perceived risk and associated higher financial costs
- Subsidized fuel markets and a lack of consideration of environmental impacts
- Complicated, costly, and multi-jurisdictional permitting processes
- Lack of regional implementation approaches
- Risk-averse culture that continues to suppress wind contribution levels.

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