



UWIG User Group Funding Proposal

Prepared by

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January, 2007

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Background and Introduction

During the past 6 years, the Utility Wind Integration Group (UWIG) has expanded its role from one of providing educational services and wind industry information to its members, to one of identifying and addressing major issues associated with the incorporation of both large and small wind plants into utility systems. UWIG has undertaken two major funded research projects to address the two most important issues raised by its members. The first of these was the operating impact study for the Xcel system to investigate the cost of ancillary services associated with wind plant operation on the system. The second was the development of a toolbox of engineering applications consisting of web-based software, application guides, and measurement and case study databases to address the problems associated with the addition of small clusters of large wind turbines on radial distribution feeders. Both of these projects were undertaken as funded activities with the support of UWIG member organizations, and resulted in approximately \$700,000 of funded work performed.

During the past three years, the UWIG has continued to experience significant growth in both membership and scope. The activities of the UWIG have continued to expand, and are now reflected in the scope and activities of its user groups, of which there are five established:

- Operating Impact and Integration Studies
- Wind Plant Modeling and Interconnection
- Distributed Wind Applications
- Market Operation and Transmission Planning
- Wind Turbine Operation and Maintenance

The user group activities have been carried out primarily on a volunteer basis, with voluntary contributions from people and organization. Utility and industry member organizations have been substantial contributors during the past three years, in addition to NREL, with whom we have enjoyed a very positive relationship, including significant parallel coordinated efforts. ERCOT has also provided substantial leadership to our efforts, as well as \$30,000 for turbine modeling work under the Wind Plant Modeling and Interconnection User Group. The breadth of the technical issues which the industry is facing is such that a better organized and more concerted effort is required to address the issues and develop solutions for the industry in a timely fashion.

In recognition of this situation, UWIG has prepared a list of ongoing and planned activities within the user groups and affiliated organizations, and developed them into a set of brief project descriptions. The list of projects has been reviewed by the UWIG members and approved by the Board of Directors. UWIG is seeking long-term resource commitments from its members and related organizations to carry out the activities which have been identified in support of the five user groups. Support is being sought through coordination of parallel efforts, or funding that can be allocated to specific projects within a user group, to a specific user group, or to the collection of user groups.

This project plan has been prepared to outline the activities proposed for each of the user groups. Some activity at a low level has already been carried out in several of the areas through UWIG or parallel efforts. For example, UWIG has been active in addressing the wind plant modeling needs of the industry as identified above with the assistance of ERCOT for the wind turbine short circuit modeling. Also, UWIG is participating in the efforts by the Western Electricity Coordinating Council in the development of wind turbine models. In the integration study area, the user group will participate in a wind energy forecasting project for Xcel through a WindLogics contract funded by the Xcel Renewables Development Fund (RDF). The user group has already started considering the implications of high penetration wind scenarios, and is benefiting from coordination with the NREL modeling work being performed by Walter Short. Three of the user groups have begun to gather best practices. This effort will go the next step in formalizing the work plans of the user groups and putting them on a more solid basis by allocating funding to achieve specific results. Ten per cent of the funds raised will be allocated to UWIG project administration overhead.

This plan is an effort to bring together in one place the important utility wind integration efforts that either are being, or need to be performed, to reduce or eliminate significant remaining barriers to increased penetration of wind energy on utility systems.

Some of the efforts have been initiated by other organizations, such as the Xcel RDF or NREL. Additional efforts may be conducted in coordination with other organizations in the future, such as DOE/NREL, EPRI, utilities, manufacturers, ISOs, state organizations such as the CEC and NYSERDA, etc. Of the first year project effort of \$1.2 million identified, approximately half is already underway with \$600k of project funding from Xcel and NREL. The goal of this plan is to identify significant remaining pieces of work that need to be done in a coordinated program context, and identify the resources necessary to carry them out, in order to provide the information necessary to remove barriers to implementation.

Approach

The UWIG philosophy to date has been to share all the results of its work with members of the organization and some of the results with the general public. UWIG would like to continue this approach as it pursues resources for the activities of its user groups. We recognize that not all members will be interested or able to fund and participate in all of the user group activities. For that reason, our approach will be to continue to encourage parallel coordinated efforts with our partners; to encourage members to contribute directly with their time; to allow members to allocate their user group funding to specific activities if they have a particular sense of priority; or to allocate their contributions to a specific user group or to the overall effort.

UWIG will encourage individual utility contributions through a solicitation of its members, and will contribute \$25,000 per year of its base funding to this effort. Special effort will be devoted to seeking the support of the organizations represented in an ex-officio capacity on the UWIG Board of Directors. These organizations represent broad cross-sections of the industry, i.e. APPA for the public power sector, EEI for the investor owned utilities, EPRI for the research community, and NRECA for the rural electric cooperatives. Similar special appeals will be made to members with a special interest in the outcomes in a particular area, i.e. manufacturers and ISOs for turbine modeling, ISOs for wind forecasting applications, and state government system benefit charge (SBC) funds for broad-based renewable energy support.

UWIG has developed a very collaborative working relationship with members and affiliated groups during the past three years in carrying out the work of the organization. A great deal of credit is due to a broad cross-section of people and organizations who have contributed time, effort, and money to enable the UWIG agenda to be carried out. UWIG intends to follow a similar approach for the next phase of the effort. A particularly strong and positive relationship has been forged with the wind program of NREL, through which topics of mutual interest and importance are identified, and carried out by NREL staff, with the results disseminated through the UWIG meetings and User Groups. We would like to build more relations of this type, in which coordinated efforts are carried out with UWIG identifying priority projects and providing review, critique, and dissemination of the results.

UWIG has existing contracts with EnerNex Corporation to provide support for several projects in the Wind Plant Modeling and Interconnection Users Group (Principal Investigator - Bob Zavadil) and the Distributed Wind Applications Users Group (Principal Investigator - Tom McDermott). EnerNex has also implemented a Google-searchable Knowledge Base for the Wind Turbine O&M User Group. These contracted efforts will be continued for the time being, under the assumption of satisfactory performance by the contractor. Support activities for the remaining projects and user groups will be competitively bid by UWIG and will be managed by UWIG staff or through staff of a member organization of UWIG. For those efforts which are carried out by affiliated organizations with their own resources, coordination will be maintained through the appropriate user group.

Project Proposals

Operating Impact & Integration Study User Group

- I. Wind Energy Forecasting System Integration
 - a. Objective: Determine the control room requirements for wind plant forecast information, and optimize the way in which such information is integrated into the control room environment.
 - b. Approach: Evaluate the impact of wind forecast information on control room operation. Define the type of wind plant output information, the frequency of delivery, the delivery mechanism, and the optimum method of control room integration. Include forecasts for both operations-planning and real-time-operations time frames, as well as the option to provide severe weather alerts. Examine alternatives to current tools used to schedule and commit generation incorporating forecast uncertainty.
 - c. Deliverable: An operating wind plant output forecasting system for control room use in both operations-planning and real-time-operations time frames. Identify improved approaches to operations planning tools incorporating wind plant output forecast uncertainty.

- II. Accommodating High Wind Penetrations
 - a. Objective: Examine increasing levels of wind penetration in alternative system expansion plans.
 - b. Approach: Identify system operating constraints associated with increasing penetration of wind power, e.g. minimum load problems, ramping capability and frequency regulation. Examine alternative approaches to accommodating increased penetration levels, e.g. flexible generating capacity, price-responsive load, curtailment and storage. Develop strategies for expansion plans to accommodate high penetration. Incorporate, to the extent possible, findings and conclusions from other studies undertaken to develop strategies for accommodating large amounts of wind power.
 - c. Deliverable: Report identifying successive constraints as a function of penetration level and strategies for dealing with them.

- III. Improved Capacity Valuation Methods
 - a. Objective: Develop improvements to existing methods used to calculate ELCC of wind plants for use in generation planning studies.
 - b. Approach: Recognizing the diurnal and seasonal nature of variation in wind plant output, modify existing reliability planning methods to incorporate the unique features of wind plants. Determine improvements over existing procedures and validate with available plant data.
 - c. Deliverable: Report documenting the effort, including data requirements of improved methods and comparison of results with other methods.

- IV. Best Practices for Wind Plant Integration
- a. Objective: Document best practices in the area of utility planning and operating practices for wind plant integration.
 - b. Approach: Survey system operators worldwide, both members and others, to identify issues and success stories associated with wind plant operation. Identify those system planning and system operating practices which have contributed to successful wind-plant integration experiences. Extract best practices and lessons learned from that experience.
 - c. Deliverable: Prepare a document of Best Practices and Lessons Learned for Wind Plant Integration. This document will be updated periodically.

Wind Plant Modeling & Interconnection User Group

- I. Wind Turbine Model Inventory and User Experience
 - a. Objective: Develop an inventory of wind turbine models available for power system simulation purposes and user experiences with them.
 - b. Approach: Work with wind turbine developers, ISOs and utilities to identify and catalog the features of existing wind turbine models for power system simulation purposes, building on information currently available. Develop a family of generic models which are adequate for transmission planning studies. Test and document user experience with both sets of models. Provide recommendations for future modeling and verification efforts.
 - c. Deliverable: Web accessible database of models available. Report on user experience.
- II. Disturbance Event Database and Model Validation
 - a. Objective: Develop a database of power system disturbances at wind plants and perform selective detailed monitoring to be used for wind turbine and wind plant model validation.
 - b. Approach: Working with utilities and wind plant owner/operators, develop a disturbance monitoring program to record and analyze power system disturbance events. Through selective monitoring of wind turbines, perform additional monitoring necessary to validate wind turbine performance models. Focus will be on models which explain the terminal behavior of the machine.
 - c. Deliverable: Disturbance database online and model validation results.
- III. Wind Turbine/Plant Modeling User Guide
 - a. Objective: Provide guidance on the use of wind turbine models in the development of wind plant models suitable for use in a range of power system simulations.
 - b. Approach: Based on experience with wind plant modeling for power system simulation, define and document a series of wind plant model development and application scenarios representative of the range of investigation covered during wind plant design and operation. Illustrate each model with a specific example

and provide a variety of case studies. Provide modeling guidelines for a range of applications.

- c. Deliverable: Modeling user guide with examples and case studies.

IV. Design Considerations for Improved Power System Operation

- a. Objective: Identify power system and wind plant design features and approaches that can lead to improved power system operations.
- b. Approach: Recognizing the unique features of the power electronic converters employed in modern wind turbines and plants, and the special requirements of the weak systems where wind plants are often located, identify power system and wind plant design features and operating capabilities which can lead to improvements in power system performance with wind plants. Improvements in voltage control, system stability, relay and protection practices, integration with EMS/SCADA systems and contribution to ancillary services will be explored.
- c. Deliverable: Report outlining current capabilities and future possibilities which can contribute to improvements in future system operations.

V. Best Practices for Wind Plant Interconnection

- a. Objective: Document best practices in the area of utility engineering for wind plant interconnection.
- b. Approach: Survey transmission system operators worldwide, both members and others, to identify issues and success stories associated with wind plant interconnection practices. Identify those engineering practices which have contributed to successful wind plant interconnection and operation experiences. Extract best practices and lessons learned from that experience.
- c. Deliverable: Prepare a document of Best Practices and Lessons Learned for Wind Plant Interconnection. This document will be updated periodically.

Distributed Wind Applications User Group

I. Distributed Wind Toolbox Support

- a. Objective: Provide enhancements and user training and support for the set of tools developed for the application of utility-scale wind turbines on distribution feeders.
- b. Approach:
 - i. Improved MultiSpeak support and additional MultiSpeak interoperability testing.
 - ii. Power-flow and short-circuit dynamic models of the four general types of wind turbine generator; Types A and B (induction machine), Type C (doubly-fed induction generator, or DFIG), and Type D (full power electronic interface). This effort includes coordination with WECC modeling efforts on transmission systems; however, the DistWind applications require models in phase coordinates, along with other features appropriate for distribution systems.
 - iii. Analysis of the monitored data at three sites to develop "virtual flicker test" reports for the monitored wind turbines, compatible with IEC 61400-21. In some cases this process will extend the UWIG turbine library. In

other cases, the measured data will be compared to vendor-supplied IEC test reports.

- iv. Additional turbine monitoring, to focus on types not presently in the UWIG turbine library for flicker calculations. More flicker models, especially for smaller turbines, will encourage use of the DistWind software by a broader audience.
 - v. User support, and the preparation of more case studies and examples.
- c. Deliverables: As outlined above, enhancements to the UWIG Distributed Wind website.

Market Operation and Transmission Policy User Group

I. Best Practices for Market Operation and Transmission Policy

- a. Objective: Document best practices in the area of market design and operation, and transmission policy as related to improved utility wind plant operation.
- b. Approach: Survey transmission system and market operators worldwide, both members and others, to identify market design principles and transmission system operating policies and practices which have been beneficial to the successful integration of wind plants into utility system and market operations. Extract best practices and lessons learned from those experiences.
- c. Deliverable: Prepare a document of Best Practices and Lessons Learned for Market Operation and Transmission Policy. This document will be updated periodically.

II. Renewable Energy Considerations in Competitive Market Design

- a. Objective: Identify unique characteristics of wind energy and changes in competitive market design necessary to remove barriers.
- b. Approach: Identify the full range of competitive electric markets (energy, capacity, ancillary services; financial transmission rights; environmental attributes) and the characteristics that are important to wind energy. As a baseline, identify the Order 888 tariff provisions that affect wind. Identify features of both regimes (Order 888 and competitive markets) that could be changed to better recognize the different characteristics of wind and reduce barriers to participation in the markets. Solicit input of utility, ISO, and wind developer communities.
- c. Deliverable: Primer on Order 888 tariff and competitive market features important to wind, differences between them and among markets, and recommendations for improvements in both.

III. Annotated Bibliography

- a. Objective: Provide a guide to important reference materials dealing with market operators and transmission policy.
- b. Approach: Identify important background documents, including reports, orders, white papers, etc. Provide annotation and key words in a searchable database with web links to the document.
- c. Deliverable: Annotated bibliography searchable by key word with web links to source material.

Turbine Operation and Maintenance User Group

- I. Wind Plant Knowledge Base
 - a. Objective: Develop and maintain a searchable and expandable knowledge base of wind plant operations and maintenance experience.
 - b. Approach: Investigate knowledge bases for existing industry applications to reflect best available technology and incorporate “lessons learned” in the design of a wind turbine/plant O&M knowledge base. Flexibility to handle multiple data and document types, and expandability of the knowledge base are important design considerations. Design, implement and maintain an on-line search engine and knowledge base. Identify issues and areas of interest suitable for ongoing user group discussion topics and expansion of the knowledge base.
 - c. Deliverable: Searchable knowledge base of wind plant O&M information.

Budget and Schedule

Table 1, First Year Project Budget Estimates, provides an estimate of the level of effort required to carry out the projects described. The Wind Energy Forecasting System Integration project, shown at a funding level of \$400,000 for the first year, is currently funded through the Xcel RDF in the amount of \$1,000,000 over a 30 month period. WindLogics is the prime contractor for the project, and UWIG is a participant.

Yellow highlighting identifies projects where a partner organization has already provided funding and taken the lead, and a coordinated activity is being carried out. In the first case, this is with WindLogics, and in the remaining cases, with NREL. The remaining efforts are shown in increments of \$25k to indicate the level of effort expected for each year. Cost estimates for new projects include a ten percent project administration overhead allocation. As can be seen from Table 1, approximately half of the first year effort of \$1.2 million is already funded through ongoing parallel coordinated effort.

Table 2, Five Year Project Budget Estimates, provides additional information on the expected 5 year level of effort associated with each project. Some of the efforts will be conducted over fixed periods, while others will continue on at some nominal level as the industry slowly matures. These activities, including the associated levels of effort and priorities, have been reviewed and refined in consultation with the user groups. It is recognized that the overall level of effort shown is unlikely to be achieved in the first year. However, this plan will provide a framework for identifying, prioritizing, and coordinating the overall effort. The individual project schedules will be determined by their priorities and the pace of the coordinated programs and fundraising effort. In the first two years, approximately half of the total effort identified is funded through parallel partner activities.

Project Management

It is anticipated that some of the projects described may be carried out by member or affiliated organizations as coordinated efforts, or as voluntary in-kind contributions to UWIG. Such projects will be carried out through a coordination agreement with UWIG, in which case the Project Manager will be selected by the sponsoring organization, with coordination provided by a UWIG project review team through the appropriate User Group.

Several existing User Group activities are being carried out by EnerNex Corporation for UWIG under a management and technical support services agreement. These include the existing project under the Distributed Wind Applications User Group, the first two activities under the Wind Plant Modeling and Interconnection User Group, a related short circuit modeling activity funded by ERCOT, and maintenance of the Turbine O&M User Group knowledge base. EnerNex is also providing key personnel to serve as chairmen of the first two User Groups under the support agreement. UWIG plans to continue this contract for the foreseeable future, contingent upon satisfactory performance by the contractor.

Other projects will be contracted through UWIG or one of its member organizations, with the subcontractor selected through a UWIG project selection panel. A Project Manager and a project review team will be provided through the appropriate User Group. All decisions are subject to final approval by the UWIG Board of Directors.

The deliverables for the projects are information products which are provided over the web, via the UWIG web site, with the exception of the Wind Energy Forecasting System for Xcel. The deliverables from WindLogics for this project, in addition to reports, include an actual operating wind plant output forecast delivered to the control room for use by the system operations and operations planning staffs for integration into the planning and operating tools.

The User Group project management effort will be led by J. Charles Smith, UWIG Executive Director, and Dr. Edgar DeMeo, Sr. Technical Advisor to UWIG. They will be assisted by Robert M. Zavadil and Dr. Thomas McDermott of EnerNex, as well as staff of member organizations. Brief biographical information for the four individuals follows.

Charlie Smith holds BS and MS degrees from Massachusetts Institute of Technology, and has thirty five years of experience in the electric power industry. He has worked for electric utilities, an equipment manufacturer, the US Department of Energy, and served as the president of a power engineering consulting company, until he formed Nexgen Energy LLC in 2003. He has served as an advisor to UWIG since it was established in 1989, and has served as its Executive Director since 2004. He is a Senior Member of the IEEE PES, and a member of CIGRE.

Ed holds PhD and ScM degrees from Brown University, and an undergraduate degree from Rensselaer Polytechnic Institute. He managed renewable energy programs at EPRI from 1976 to 1998. In 1999, he formed Renewable Energy Consulting Services, Inc., through which he provides program management and technology development support to national and state

renewable energy programs. He is a member of IEEE and a strategic advisor to the DOE/NREL Wind Energy Program and UWIG.

Bob Zavadil holds the BSEE degree with highest honors from South Dakota State University. He is a cofounder and Vice President of EnerNex Corp, where he is responsible for developing and overseeing the company's power system engineering consulting business. He has worked on electric power system issues for wind generation for more than 15 years. He is a member of IEEE and serves as the Secretary of the IEEE PES Wind Power Coordinating Committee. He is a registered professional engineer in the State of Nebraska.

Tom McDermott holds the PhD degree from Virginia Polytechnic Institute and the degrees of BS EPE and MS EPE from Rensselaer Polytechnic Institute. He is a Senior Consulting Engineer with EnerNex Corporation, and is a recognized expert in circuit simulation, distribution systems, lightning protection, insulation coordination, power quality data analysis, and the development of software tools. Tom is a Senior Member of IEEE, past Chairman of the IEEE PES Pittsburgh Section, and past Secretary of the IEEE PES Distribution System Analysis Subcommittee. He is a registered professional engineer in the State of Pennsylvania.

Tables

User Group Projects	2007
Operating Impacts and Integration Study	
Wind Energy Forecasting System Integration	\$400,000
Coping With High Wind Penetrations	\$100,000
Improved Capacity Valuation Methods	\$50,000
Best Practices for Wind Plant Integration	\$25,000
Subtotal	\$575,000
Wind Plant Modeling and Interconnection	
Wind Turbine Model Inventory and User Experience	\$100,000
Disturbance Event Database and Model Validation	\$50,000
Wind Turbine/Plant Modeling User Guide	\$50,000
Design Consideration for Improved Power System Operation	\$50,000
Best Practices for Wind Plant Interconnection	\$50,000
Subtotal	\$300,000
Distributed Wind Applications	
Distributed Wind Toolbox Support	\$100,000
Subtotal	\$100,000
Market Operation and Transmission Policy	
Best Practices for Market Operation and Transmission Policy	\$25,000
Renewable Energy Consideration in Competitive Market Design	\$100,000
Annotated Bibliography	\$25,000
Subtotal	\$150,000
Wind Turbine Operations and Maintenance	
Wind Plant Knowledge Base	\$100,000
Subtotal	\$100,000
TOTAL	\$1,225,000

Table 1: First Year Project Budget Estimates

User Group Projects	2007	2008	2009	2010	2011	Total
<u>Operating Impacts and Integration Study</u>						
Wind Energy Forecasting System Integration	\$400,000	\$400,000	\$200,000			\$1,000,000
Coping With High Wind Penetrations	\$100,000	\$50,000	\$50,000			\$200,000
Improved Capacity Valuation Methods	\$50,000	\$50,000				\$100,000
Best Practices for Wind Plant Integration	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$125,000
Subtotal	\$575,000	\$525,000	\$275,000	\$25,000	\$25,000	\$1,425,000
<u>Distributed Wind Applications</u>						
Distributed Wind Toolbox Support	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$500,000
Subtotal	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$500,000
<u>Market Operation and Transmission Policy</u>						
Best Practices for Market Operation and Transmission Policy	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$125,000
Renewable Energy Consideration in Competitive Market Design	\$100,000	\$100,000	\$50,000			\$250,000
Annotated Bibliography	\$25,000		\$25,000		\$25,000	\$75,000
Subtotal	\$150,000	\$125,000	\$100,000	\$25,000	\$50,000	\$450,000
<u>Wind Plant Modeling and Interconnection</u>						
Wind Turbine Model Inventory and User Experience	\$100,000	\$100,000	\$100,000	\$50,000	\$50,000	\$400,000
Disturbance Event Database and Model Validation	\$50,000	\$50,000	\$50,000	\$25,000	\$25,000	\$200,000
Wind Turbine/Plant Modeling User Guide	\$50,000	\$50,000	\$50,000	\$25,000	\$25,000	\$200,000
Wind Plant Design Considerations for Improved System Operation	\$50,000	\$50,000				\$100,000
Best Practices for Wind Plant Interconnection	\$50,000	\$25,000	\$25,000	\$25,000	\$25,000	\$150,000
Subtotal	\$300,000	\$275,000	\$225,000	\$125,000	\$125,000	\$1,050,000
<u>Wind Turbine Operations and Maintenance</u>						
Wind Plant Knowledge Base	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$500,000
Subtotal	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$500,000
TOTAL	\$1,225,000	\$1,125,000	\$800,000	\$375,000	\$400,000	\$3,925,000

Table 2: Five Year Project Budget Estimates