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Wind for Schools: Developing Education Programs to Train the Next Generation of the Wind Energy Workforce

Preprint

I. Baring-Gould, L. Flowers, and M. Kelly
National Renewable Energy Laboratory

L. Barnett
U.S. Department of Energy

J. Miles
James Madison University

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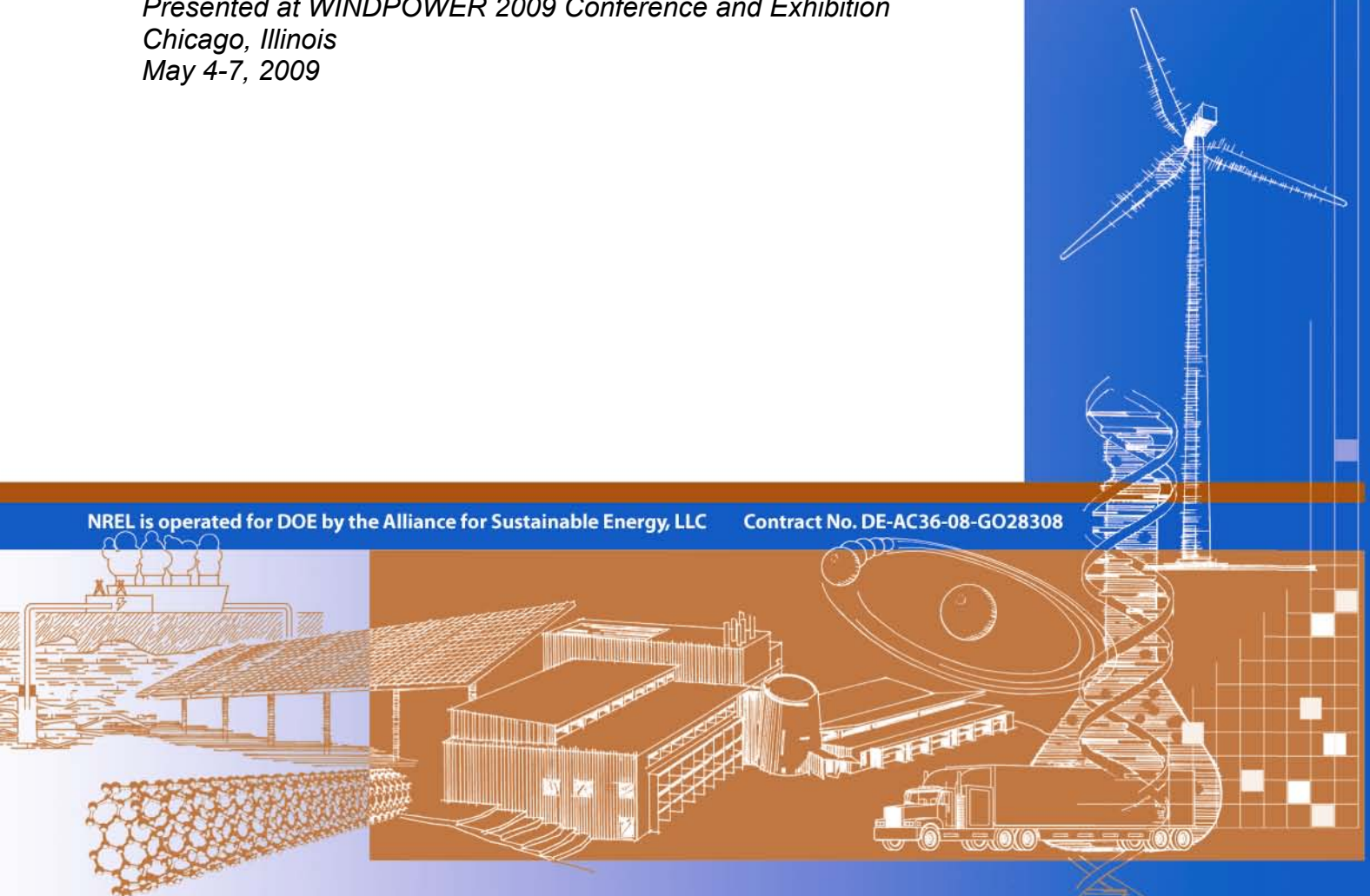

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WIND FOR SCHOOLS: DEVELOPING EDUCATION PROGRAMS TO TRAIN THE NEXT GENERATION OF THE WIND ENERGY WORKFORCE

E. Ian Baring-Gould, Larry Flowers, and Marguerite Kelly
National Renewable Energy Laboratory
Golden, Colorado, USA
ian.baring_gould@nrel.gov, larry.flowers@nrel.gov, marguerite.kelly@nrel.gov

Lisa Barnett
U.S. Department of Energy, Wind and Hydropower Technologies Program
Washington D.C., USA
lisa.barnett@ee.doe.gov

Jonathan Miles
James Madison University
Harrisonburg, Virginia, USA
milesjj@jmu.edu

ABSTRACT

As the United States moves toward a vision of greatly expanded wind energy use, the rapidly growing wind industry faces two challenges: a critical need for skilled workers trained in wind energy technology and the need to address local concerns caused by a lack of understanding of the true issues and real benefits of wind energy development. The U.S. Department of Energy's Wind for Schools project aims to address these two critical issues.

The Wind for Schools project works to engage local citizens in a wind energy discussion while developing a knowledge base for wind energy within schools. The project's three primary goals are to (1) engage rural elementary and secondary school teachers and students in wind energy education; (2) equip college students in wind energy applications while starting a nucleus for expanded programs to provide the growing wind industry with and interested and equipped workforce; and (3) introduce wind energy on a small scale to communities, starting a discussion of the benefits and issues in using wind energy to meet the needs of the nation's and the world's energy future.

The general approach of the Wind for Schools project is to install small wind turbines at rural elementary and secondary "host" schools while developing wind energy application centers at higher education institutions. Teacher training and hands-on curricula are implemented at each host school to bring the wind turbine into the classroom through interactive and interschool wind-related research tasks. The students at the wind energy application centers assist in the assessment, design, and installation of the small wind systems at the host schools. They also participate in class work and other engineering projects in the wind energy field.

This paper provides an overview of the project elements, including a description of host and collegiate school curricula developed for wind energy and the status of the current projects. The paper also provides focused information on how schools, regions, or countries can become involved or implement similar projects to expand the social acceptance and understanding of wind energy.

Keywords: Wind, workforce, education, schools

1 Introduction

In 2006, President Bush emphasized the nation's need for greater energy efficiency and a more diversified energy portfolio. This led to a collaborative effort of more than 70 organizations led by the U.S. Department of Energy's (DOE's) Wind and Hydropower Technologies Program, the American Wind Energy Association, and the national laboratories to explore a modeled energy scenario in which wind provides 20% of U.S. electricity. The purpose of the 20% Wind Energy by 2030 report, released in July 2008 [1], is to begin a dialogue about issues, costs, and potential outcomes associated with the 20% wind scenario. Although the report clearly indicates that this ambitious 20% wind scenario is achievable, it also highlights the challenges to overcome.

One of the challenges of providing 20% of U.S. electricity from wind by 2030 is a need for a

dramatically expanded trained workforce. The 20% wind energy by 2030 report estimates a direct U.S. wind workforce of approximately 180,000 by 2030 to support the implementation of approximately 16 GW of new capacity per year (Figure 1). The development of a national educational infrastructure will be a cornerstone to the successful creation of a green energy economy in the United States. President Obama expanded on this theme from the early days of his administration, describing the hundreds of thousands of jobs to be produced from a transition to a green energy economy, many of which will come from the expansion of the wind industry.

The need to develop infrastructure to train this future workforce, combined with the 40% expansion in the total installed capacity of wind turbines in 2008 (a record 8,300 MW), is a priority for the U.S. wind industry.

In addition to this general pressing need for a trained workforce, the perception that energy can be taken for granted within our society is changing as the economic and environmental impacts of our current energy supply structure are more widely understood. The U.S. Department of Energy's Wind Powering America project, led technically by the National Renewable Energy Laboratory (NREL), sponsors the Wind for Schools project to raise awareness in America about the benefits of wind energy while simultaneously developing a wind energy knowledge base in future leaders of our communities, states, and nation.

The three primary project goals of the Wind for School project are to:

- Engage rural school teachers and students in wind energy
- Educate college students in wind energy applications, which will equip engineers for the growing U.S. wind industry
- Introduce wind energy to rural communities, initiating a discussion of wind energy's benefits and challenges.

The Wind for Schools project approach is to implement a wind energy training center at state-based universities or colleges. As part of the wind energy curriculum activities, college students would assist with installing small wind turbines at primary and secondary schools.

A wind turbine located at a school also provides students and teachers with a physical example of how communities can take part in providing for the economic and environmental security of the nation while allowing exciting, hands-on educational opportunities for the students.

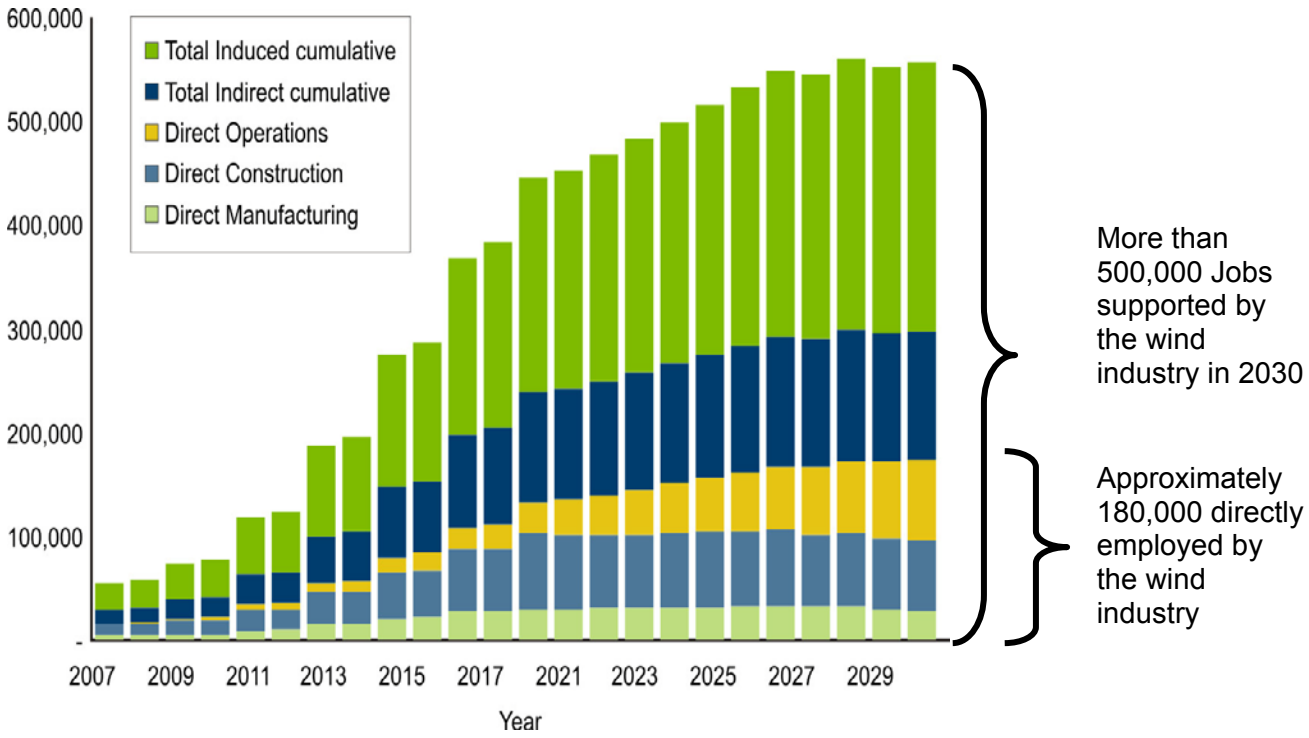

Figure 1: The 20% wind energy by 2030 report estimates a direct U.S. wind workforce of approximately 180,000 to support the implementation of approximately 16 GW of new wind capacity per year.

The project implementation also provides solid experience for the college students that, when combined with wind energy coursework, prepares them to enter the wind energy workforce. It is expected that through this project, small wind turbines will be installed at five to eight new schools in each targeted state each year.

2 Expanded Need for Workforce Development

All other primary energy industries have extensive training infrastructure in place, helping to ensure a steady stream of engineers, scientists, and developers entering each individual field. As an example, schools initially focusing on mining in Colorado, South Dakota, Nevada, Montana, and other states support training of engineers and other experts for the oil, natural gas, and coal industries. Although a number of universities and community colleges are starting to develop new wind education and/or training programs, no such infrastructure currently exists for the wind industry.

There is a dramatic short-term need for wind technical experts and individuals who can deploy and maintain wind projects. Long-term educational pathways (such as exist in other major energy sectors) must also be developed, which would ensure the workers needed to fulfill the industry's current needs, as well as continued improvement and expansion 10 and 20 years from now. This includes developing continuity among all levels of the educational sector, training teachers and professors to expand the knowledge base, and developing pathways to allow individuals currently in related fields to obtain the expertise they will need to support the wind energy industry. Figure 2 graphically portrays the workforce development needs of a vibrant wind industry.

Activities must be implemented that target all levels of the education system—primary schools through research university-based post graduate programs—to support a vision in which a significant portion of the nation's (and world's) energy comes from wind technologies. These programs must also be broad in spectrum, training engineers as well as plant operators, technicians, biologists, lawyers, and businesspeople. Educational systems stakeholders must also understand that each of these professions will be needed in different numbers and require different training times, from

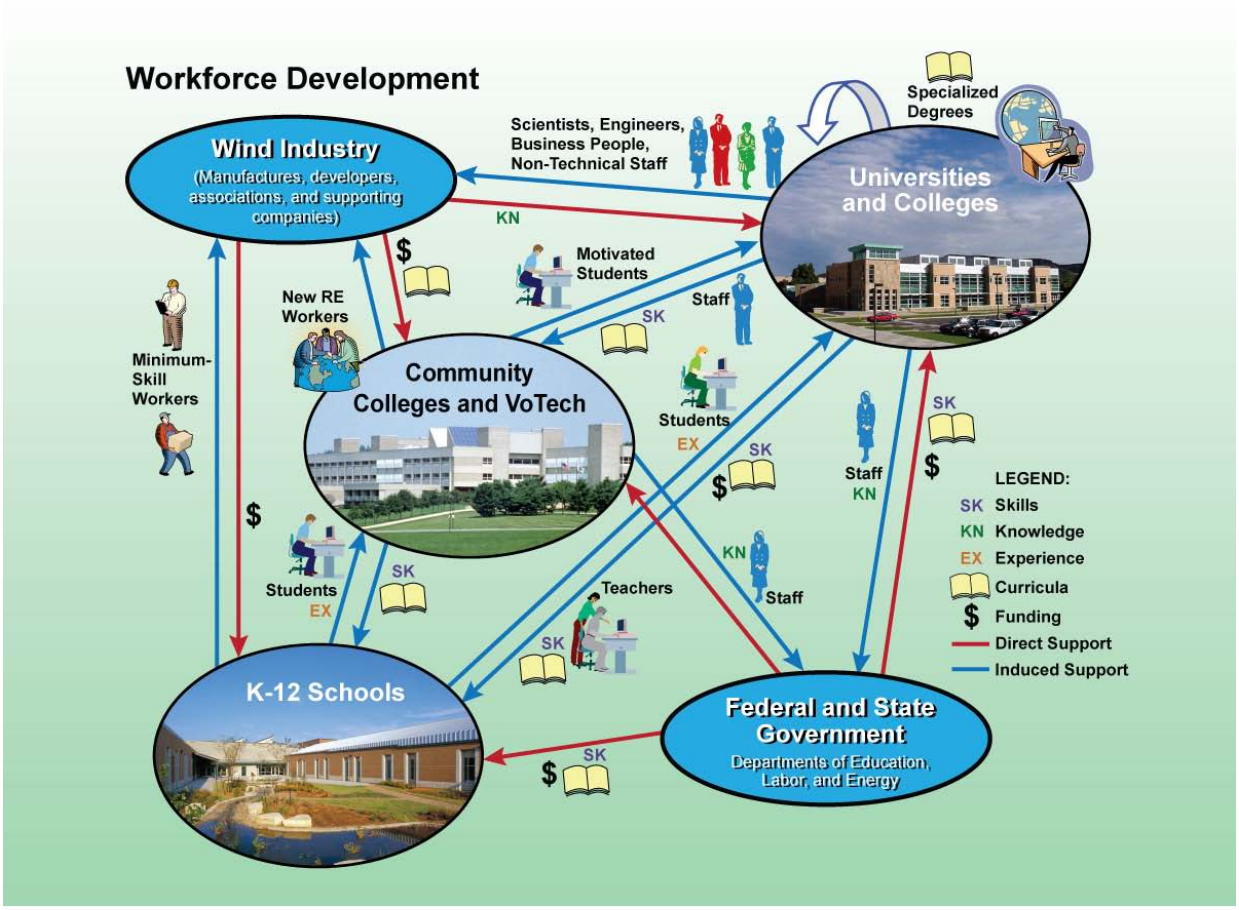

Figure 2: Workforce development infrastructure pathways to support a dynamic wind industry.

several weeks to many years. The Wind for Schools project is one element of a larger activity to support expanded workforce development needs for the U.S. wind industry.

3 The Wind for Schools Project

The main focus of the Wind for School activity is to develop the Wind Application Center (WAC) in identified states and, through these organizations, support the installation of Wind for Schools systems at schools as part of a larger education package. Eight entities are involved in the implementation of each Wind for Schools system: the school (which includes a science teacher, the school administration, and the community); a WAC; a state facilitator; Wind Powering America/NREL; a green-energy-sponsoring company; a wind turbine manufacturer; the local utility or electric cooperative; and the state energy office. Although the structure is not rigidly defined (to allow different states to implement the project as is most appropriate), the following section describes the roles and responsibilities of each entity in greater detail. Figure 3 depicts the Wind for Schools program structure, showing the links and general activities undertaken by each of these organizations.

Host school, science teacher, school administration, and community: In order for a Wind for Schools project to succeed, people at all levels within the school community must support the concept: the science teacher, the school principal and administration, the district superintendent and administration, and the school board. The school provides land for the project, support for the wind turbine interconnection to the school electrical system, facilities support, financial support, and support for the project in community meetings, site permitting, and other organizational events. After the installation, the science teacher uses the wind turbine as a teaching aid in energy-related curricula and possibly as a source for science fair concepts. The program supplies curricula, educational kits, and training to teachers to support wind curricula implementation in the classroom. Although project financial structures will vary from state to state, the schools own and are responsible for the wind turbine system. The schools will save a minimal amount of money by offsetting power generation.

Wind Application Center (WAC): A WAC is implemented at a state university or college under the leadership of an interested university professor. The WAC will implement a wind energy curriculum and will graduate engineers and systems analysts, some of whom may pursue wind energy as a career. Roughly fashioned after the Industrial Assessment Centers and working

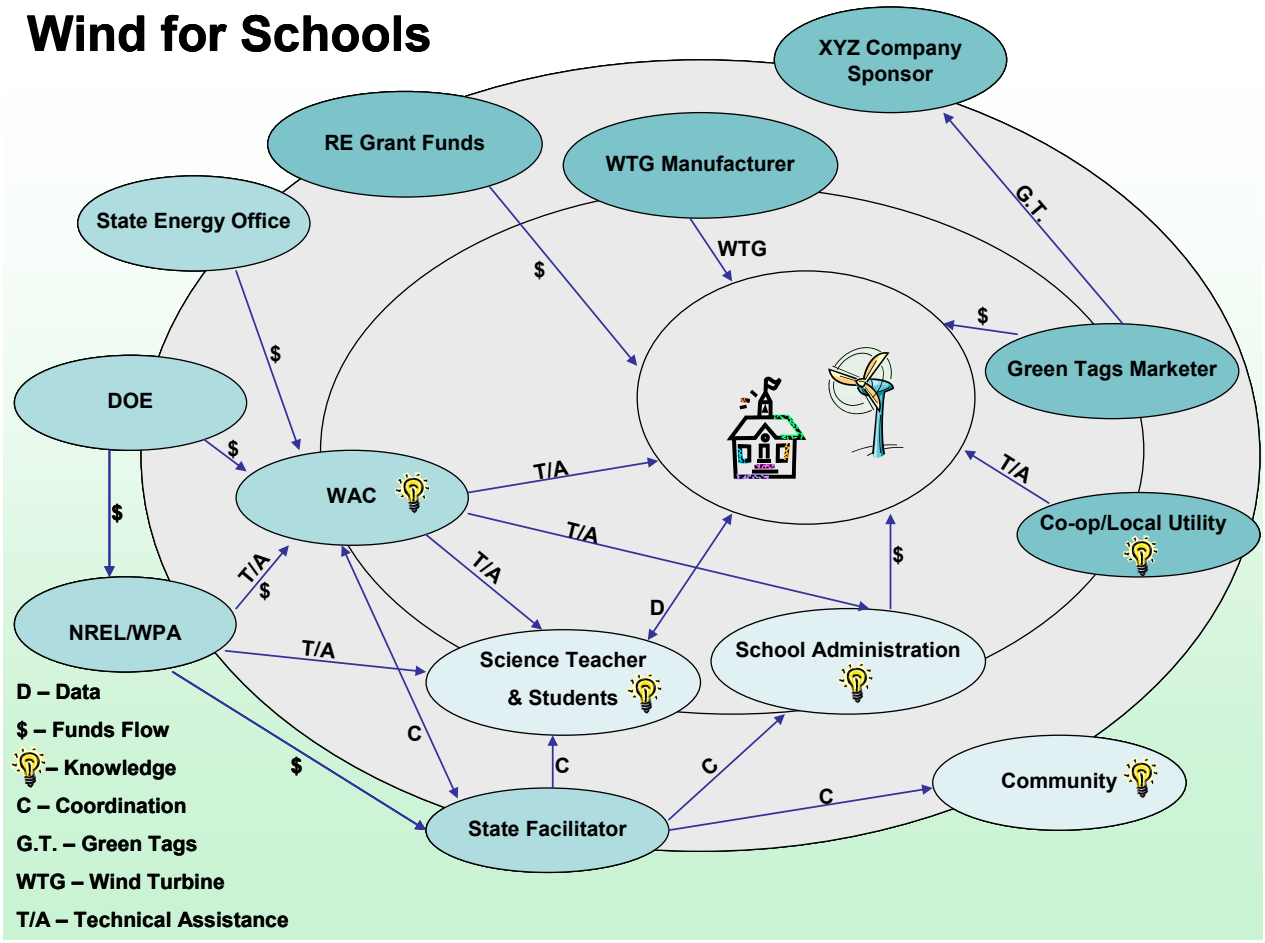

Figure 3: Schematic of the Wind for Schools program.

with the state facilitator, the WACs will also provide technical assistance to rural schools (analyzing the wind resource, energy usage, siting, permitting, land use, and financials, as well as overseeing the installation of the power system and analyzing system performance data).Typically new candidate schools will be identified in the early fall, with students from the WAC conducting analysis and system permitting during the fall academic semester. The turbines will be installed in the spring or summer, possibly as a junior or senior academic project. This project implementation experience, combined with wind curricula offered through the WAC, will help to produce graduate engineers and systems analysts knowledgeable in the wind application process.

After the 3- to 5-year implementation period, the WAC will assume the responsibilities of the state facilitator and will become the primary repository of wind energy applications knowledge and expertise. Schools, small business owners, residential users, state policymakers, regulators, and other stakeholders will view the WAC as the source of information regarding wind energy applications. Although Wind Powering America/NREL will provide technical and financial support to develop the WAC, it is anticipated that after the implementation period the WAC will identify independent funding sources.

The success of the WACs is one of the long-term goals of the Wind for Schools project.

State facilitator: This individual or organization assists Wind Powering America in developing the Wind for Schools project in each state. The facilitator's primary responsibility is to identify candidate K-12 host schools and support the project's development by working with the local communities and school administrators. The state facilitator is also responsible for working with Wind Powering America and the WAC to line up funding and implement each project. The facilitator's role is designed to last about 3 years, at which point the WAC assumes the facilitator responsibilities. Wind Powering America will provide initial funding for the state facilitators.

Wind Powering America/NREL/DOE: In each state, Wind Powering America will provide technical and financial assistance to the WAC and state facilitator over the first few years of the project, including:

- Conducting the annual wind energy applications training program
- Assisting in the analysis of Wind for School projects
- Providing analysis models and other tools to support project development
- Providing turbine installation and commissioning procedures training
- Providing wind resource assessment equipment
- Assisting in curricula development for the K-12 schools and the WAC
- Hosting students, professors, and teachers with summer projects at NREL.

Green energy certificate sponsoring companies: The energy from the wind turbines will offset a modest amount of energy usage at the school. The green attributes for the energy produced by the Wind for Schools turbines will be sold to defray the wind turbine costs. The sponsoring company will pre-purchase the environmental attributes (green tag production) from the turbine over the first 10 years of operation for a fixed amount, typically $2,500.

Wind turbine manufacturer: Southwest Windpower (www.windenergy.com) joined the Wind for Schools project as the initial supplier of all Wind for Schools systems. The standard system incorporates a SkyStream 3.7 wind turbine on a 70-ft guyed tower. This 2.4-kW wind turbine will produce about 3,600 to 4,000 kWh/year, depending on annual average wind speeds. Several tower options are also available at additional cost, including a monopole (self-supporting tower without guy wires).

Local utility or electric cooperative: To ensure the success of a Wind for Schools project, the local electricity provider should be involved. The utility or cooperative should provide technical expertise (both in terms of installation and education) and assist in the installation of the wind turbine and associated hardware. The school and state facilitator (or the WAC after the initial years) will be expected to secure the support and assistance from the local provider. Community education is one of the goals of the Wind for Schools project, and the local electricity provider is a critical project partner. In most rural areas, the local utility or energy cooperative is one of the key community members, an entity that supplies the services that have expanded development and the quality of life. The Wind Powering America program supports an environmentally sustainable energy economy, including the expanded use of wind energy, as a way to bring prosperity to communities. The local electricity providers play a special role in assisting this development opportunity, although many are hesitant because of lack of experience with wind technologies. The Wind for Schools project hopes to help bridge this experience gap. Also, partnering with the local

schools and the Wind for Schools project provides an opportunity for local energy organizations to highlight the importance of energy in our society.

State energy office: The state energy or development office provides technical, financial, and managerial support for the project as appropriate through the WAC and state facilitator. Additionally the state energy office will assist in the funding the Wind for Schools projects, either directly or by identifying grants and other funding opportunities.

Each of these groups plays an active role in the support of the program and must work collectively to support its operation.

4 The Wind for Schools System

Although project organizers understood that some schools might be interested in implementing different turbine models, the focus of the Wind for Schools activity is to implement the technology for primarily educational purposes. Using these conditions as the primary driver, the Wind for Schools system must 1) be easy to implement and interconnect to the school's electrical grid, 2) be small enough so that all of the system generation will be used at the school, and 3) have integrated data logging to provide data for students to consider.

4.1 The Wind for Schools system

The following components are part of a standard WPA Wind for Schools project system (Figure 4).

1) SkyStream™ 3.7, 2.4-kW wind turbine [2]
2) A standard 70-ft guyed or equivalent monopole tower (supplied by Southwest Windpower)
3) Turbine electrical box and fused disconnect
4) The main foundation for the turbine and tower, including tower base electrical grounding. Specific foundation design will depend on the type of tower and soil conditions.
5) Tower guy wire foundations and electrical grounding. Guy wire foundations would not be needed with a monopole tower installation.
6) School electrical connection. The interconnection between the turbine and the school will be completed with a buried electrical cable.
7) School disconnect and junction box. This junction box is typically located where the wind turbine electrical wires enter the school building.
8) School's electrical power meter or interconnection point, where the turbine is electrically connected to the school's 240-V or 208-V electrical system. This should be connected on the school's side of the electrical meter.

4.2 Project Costs

NREL/DOE provides financial support for the facilitator and WAC during the initial project years but typically do not directly provide funding for the purchase of the turbine hardware. The state energy office identifies funding sources for the partial purchase of the turbine hardware. An installed Wind for Schools system costs between $15,000 and $20,000 to install commercially, depending primarily on the tower type selected. Between $7,000 and $10,000 of this amount is for equipment and other system-specific hardware. The school will provide approximately $1,500 to $2,500; the sale of the turbine's environmental benefits will provide approximately $2,500; and

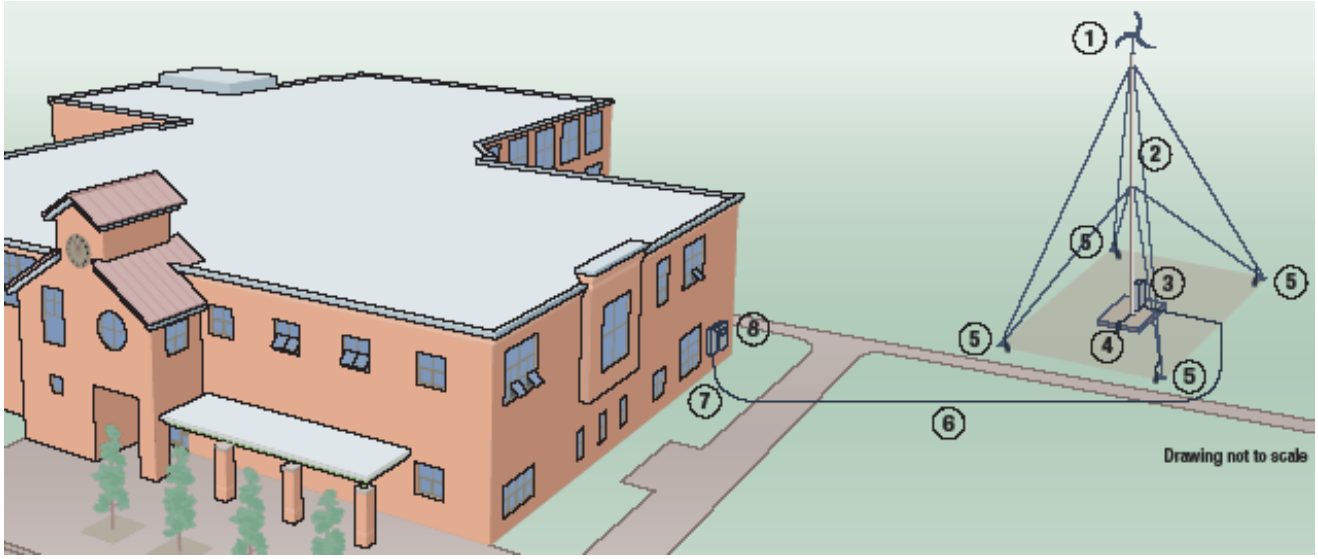

Figure 4: Schematic of a typical Wind for Schools system installation.

state-based grants, local donations, or equipment buy-down will provide the remaining funds. Many project participants donate their time, and the local utility or co-op is strongly encouraged to provide in-kind and material support for the turbine installation. Other funding options, such as low- or no-interest loans, a revolving loan fund, or other financial assistance, may be available from state organizations or local benefactors. Part of the facilitator's role is to identify the potential sources of additional state funding that may be applied to wind projects.

4.3 Curricula

Through the Wind for Schools program activity, curricula are developed and implemented at both the university and K-12 level. The program currently does not work directly with community colleges or other vocational programs.

One of the project goals of Wind for Schools is to educate college students in wind energy applications, a goal that requires a number of institutions of higher education throughout the United States to establish WACs, entities that provide the key elements of support for Wind for Schools within each state.

The primary responsibilities of a WAC are to provide technical assistance to schools and develop and implement university-based wind energy curricula as one step toward graduating engineers, systems analysts, and other majors who are knowledgeable in the wind application process and motivated to pursue wind energy as a career. Curricula is developed and shared among the WACs, each typically focusing on specific technical areas that are the strengths of the respective professors and institutions.

The Wind for School systems installed at the primary and secondary schools play a key role in the development of this experience. Through the implementation of the projects at the schools, students from the WACs gain valuable experience in the implementation of wind projects, from resource assessment through site selection, permitting, and installation. Although these activities are for a small project, they mirror experiences that are applied on a much bigger scale with large projects. The WACs also address the need to stimulate further interest in the renewable sector by engaging with and fostering relationships between universities and K-12 schools and recognizing the mutual benefits gained as university students learn not only through classroom instruction, but also by participating as "consultants-in-training." Likewise, the relationship between the university and K-12 school provide young students and their teachers the opportunity to mine university resources for ideas and assistance and to apply context to principles of mathematics, science, and other subjects that are applicable and of growing interest at all levels. Currently in the U.S. academic system, fewer students are choosing to enter scientific fields. Early positive experiences with science and engineering are more likely to lead to students entering scientific fields.

Providing educational opportunities at the primary and secondary level is also crucial to the project's aim of developing a workforce for the future. This aspect is completed by implementing age-appropriate curricula produced by the American Wind Energy Association, the NEED project [3], and KidWind [4]. This hands-on, interactive curricula is implemented through teacher training workshops in each of the states, sponsored by the Wind for Schools project. The program also provides teacher training science kits for use in the classroom.

Following further development to implement data systems at each of the school projects, data from each of the turbines will be uploaded to a central Wind for School data repository, allowing free access of the data to all schools. As part of the development of this data-sharing capability, further curricula is being developed to allow expanded science-based educational opportunities, such as comparing the output of the turbines at different locations and in different wind resource areas. It is expected that the availability of data from across the Wind for Schools project will lead to expanded curricula developed at individual schools or through dedicated science projects, all shared throughout the Wind for Schools network.

5 Affiliates Program

As of mid-2009, the Wind for Schools program is active in six states with plans for modest expansion. However, states and individual communities are interested in becoming involved in wind energy education. For this reason, the Wind for Schools project has implemented an affiliates activity to engage individual K-12 schools or states to initiate educational programs that are modeled after the Wind for Schools program activities, but without specific financial support from the formal DOE Wind for Schools project. By becoming an official program affiliate, an institution will be provided access to program support functions, Web sites, and information. The program is organized to support individual schools that wish to implement wind-related educational curricula and install a Wind for

Schools system, or states that intend to implement a full statewide program.

In all cases, WPA does not provide funding to directly support the activities of a Wind for Schools affiliate but would provide an appropriate level of technical assistance and make available all program resources and documentation for support of the program. State programs and individual school projects would be responsible for all organizational responsibilities associated with the implementation of an affiliates program.

6 Results

The Wind for Schools project is still in its relative infancy (many of the WACs began operation in the spring of 2008). The program is active in only six U.S. states: Colorado, Kansas, Nebraska, South Dakota, Montana, and Idaho. In each state, WACs have been implemented and classes (including wind technology) are offered at each institution. Sixty-six students graduated in fall 2008 after completing a class that included some amount of wind energy education. Additionally, during the spring 2009 semester, 61 students are involved in WAC activities and a total of 17 Wind for Schools systems, such as the one at Greenbush High Schools in Kansas (Figure 5), have been installed at host K-12 schools. Twenty-seven additional host schools have been identified with installations expected over the summer and fall of 2009.

7 Acknowledgements

This work was funded by the U.S. Department of Energy, Wind and Hydropower Technologies Program and is conducted by the Wind Powering America Program at the National Renewable Energy Laboratory with the assistance of staff from the Idaho National Laboratory. The success of these activities is made possible through the work of the Wind for Schools state facilitators, staff of the WACs, and science teachers and the administrators at current and future Wind for Schools host schools, whose dedication to future generations makes this program possible.

References

[1] *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply.* U.S. Department of Energy, July 2008. http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

[2] Skystream turbine, http://www.skystreamenergy.com/

[3] The NEED Project, http://www.need.org/

[4] KidWind, http://www.kidwind.org/

Figure 5: Wind for School system installed at Greenbush High Schools, Kansas. PIX # 16245/Josh Cochran.

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As the United States moves toward a vision of greatly expanded wind energy use, the rapidly growing wind industry faces two challenges: a critical need for skilled workers trained in wind energy technology and the need to address local concerns caused by a lack of understanding of the true issues and real impacts of wind energy development. The U.S. Department of Energy's Wind for Schools program aims to address these two critical issues. The Wind for Schools program works to engage local citizens in a wind energy discussion while developing a knowledge base for wind energy within schools. The project's three primary goals are to (1) engage rural elementary and secondary school teachers and students in wind energy education, (2) equip college students in wind energy applications while starting a nucleus for expanded programs to provide the growing wind industry with an interested and equipped workforce, and (3) introduce wind energy on a small scale to communities, starting a discussion of the benefits and issues in using wind energy to meet the needs of the nation's and the world's energy future. This paper provides an overview of the project elements, including a description of host and collegiate school curricula developed for wind energy and the status of the current projects. The paper also provides focused information regarding how schools, regions, or countries can become involved or implement similar projects to expand the social acceptance and understanding of wind energy.

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