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FINAL PERFORMANCE REPORT

For the Period February 1, 1995 through September 30, 1996

**US Department of Energy
Museum Science Education Program**

January 20, 1997

Project Title:

Wind Power Live! An Interactive Exhibit and Related Programs about Wind
Generated Energy at the Science Museum of Minnesota

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**US Department of Energy
Museum Science Education Program**

**Patrick Hamilton
Wind Power Live! Project Director
January 20, 1997**

This report is organized according to the goals and outcomes that were listed in the original grant proposal to the US Department of Energy.

Goals and Outcomes for Wind Power Live!

Goal 1. Wind Power Live! will help museum visitors understand wind and why it is being seriously considered as a significant source of energy for Minnesota and the Upper Midwest.

- Outcome 1a) Visitors will be introduced to a wind turbine and learn how wind is converted into electricity.
- Outcome 1b) Visitors will learn what is meant by intermittent renewable energy.
- Outcome 1c) Visitors will gain an understanding of how wind-generated electricity can be fed into an electrical grid to meet regional energy needs.
- Outcome 1d) Visitors will learn why the potential for wind energy in Minnesota is so high relative to most of the U.S. (class 4 or higher)
- Outcome 1e) Visitors will be presented with wind maps showing wind potential across Minnesota and the Upper Midwest.

A 15-minute demonstration "*What's Up With Wind*" is presented several times a week to visitors to the *Wind Power Live!* exhibit. A presenter explores the question, "where does wind come from?" first by recounting the explanations given by several cultures and then by using a series of props and audience participation activities to outline the view of Western science. Visitors learn about the sun's effect on the movement of air molecules and air masses and then learn about the regional aspects of wind regimes and how this affects our ability to capture the energy of the wind to make electricity.

"A Long-winded Tale" is an exhibit component that shows the centuries-old history of wind power through photos and artifacts. From the entrance of the exhibit hall, visitors see three large, historic wind machines - an Aeromotor water-pumping windmill, a 1930's Jacobs wind electric plant, and a Wincharger, used to bring radio to pre-REA farms. Visitors read and see examples of wind machines from across the world and across the centuries.

A theater piece entitled *"Blowin' in the Wind"* brings the nuts and bolts of making electricity from the wind down to earth and uncovers some of the issues behind the question "who owns the wind"? In a twist on the old "traveling salesman" plot, a person is sent out to meet with several residents of western Minnesota in order to buy their wind rights. The real-world questions and concerns about wind power are illuminated as well as the value of this new-found resource.

"Welcome to Buffalo Ridge" is an exhibit component that takes visitors to Buffalo Ridge in western Minnesota and the wind turbine installation where utility-scale electricity generation is taking place. A series of photos, maps, and copy orients visitors to the area and explains the wind resource and electricity-generating potential held by the Upper Midwest. Behind a knee wall is a large, three-sided photographic mural. By turning a hand crank, a visitor can rotate mural through the three images. The first photograph is of a native prairie, the landscape that covered much of the Upper Midwest for thousands of years. The second mural image shows this prairie transformed into cropland. The third shows wind turbines spread throughout rolling field of soybeans, representing a newly discovered "crop" for the Upper Midwest.

Adjacent to the discussion of large-scale wind turbines, *"I Get My Electricity From the Wind"* tells the tales of individuals and cooperatives who harness wind on a smaller-scale. Visitors can read newspaper accounts or scan the photos and words of individuals as they describe how they succeeded in making wind work for them.

Goal 2. Wind Power Live! will enable people to visualize the dynamics and power output of turbines through an innovative computer display.

- Outcome 2a) Visitors will interact with computer models of wind speed and energy output from a 100-mW wind farm in southwestern Minnesota, 200 miles away.
- Outcome 2b) Visitors will also be able to see the relation between wind speed and power output from the wind farm over a variety of time periods, from the present to the last four weeks.

"Test-a-Turbine" is an interactive activity station at which visitors can explore the relationships between wind speed and turbine blade length and the electricity output of a small-scale turbine. Visitors can experiment in a small wind tunnel with a small working turbine with interchangeable blades of varying lengths. The electrical output of the turbine is fed to a computer where it is graphed so that visitors can see the data from their experimental trials. A tutorial on the computer helps them interpret their results and helps explain some of the theory behind the differences they see in electrical output.

Goal 3. The Science Museum hopes to introduce its audiences to a working wind turbine.

- Outcome 3a) SMM will install wind monitoring equipment to gauge the potential for a small, residential-scale wind turbine to be installed at its new riverfront site.
- Outcome 3b) Depending on the outcome of the above study, SMM might install, operate, maintain, and interpret a small-scale (approximately 3 kW) wind turbine.

The original Department of Energy award for Wind Power Live! was \$199,000. It was then scaled back to \$159,700. The Science Museum, consequently, needed to scale back its plans for the exhibit and decided not to install wind monitoring equipment at its new riverfront site. The museum, therefore, did not install a small-scale working wind turbine, but Wind Power Live! does have on display a small turbine manufactured by World Power Technologies of Duluth, Minnesota.

Goal 4. Wind Power Live! will showcase wind as a technological success story.

- Outcome 4a) Visitors will discover how rapid organizational learning and small modular size have enabled wind technology to evolve rapidly over the past decade.
- Outcome 4b) Visitors will learn about the latest technological advances and trends, such as variable speed motors and larger-sized turbines.
- Outcome 4c) Visitors will learn how the price of wind-generated electricity has dropped significantly over the past two decades.

In the *"Welcome to Buffalo Ridge"* and *"I get my Electricity from the Wind"* exhibit components, visitors see a wide variety of machines and applications that make wind power a very real, economical and environmentally favorable alternative energy source. The story of a Danish cooperative where landowners join to operate larger, efficient wind turbines, the story of an elementary school in Iowa that produces its power from an on-site wind turbine, the story of a North Dakota monastery whose sisters wanted to promote stewardship of the earth through the use of alternative energy, and the story of a five-year-old boy who says "I have an electric train and it runs on the wind and sun" join with the story of utility-scale wind development in western Minnesota to show the flexibility and feasibility of wind as an alternative energy source.

The exhibit component, *"A Long-winded Tale,"* outlines the development of wind machines over many centuries, while a scene in the theater piece, *"Blowin' in the Wind"* outlines recent technological advances and various designs of turbines currently in use.

An interactive computer program titled *"Ask the Wind Kids,"* (starring high-school students from the Science Museum's Projects Club) answers frequently asked questions about wind power. Entertaining and visually striking special effects help demonstrate ideas and principles such as *"what's so good about wind power?"*, *"how big is a wind turbine?"* and *"what's a megawatt?"*

An activity bench entitled *"Wind Works"* allows children to turn on a small wind tunnel that drives a small wind turbine. They then can hook various electrical devices up to the turbine and see that wind can be used to power lights, pump water, run a whimsical toy, charge a capacitor, and run a clock. Children are asked to imagine all the things that wind power could do.

Goal 5. Wind Power Live! will consider the environmental costs and benefits of wind energy.

- Outcome 5a) Visitors will understand the role of renewable sources of energy in mitigating regional and global environmental problems.
- Outcome 5b) Visitors will learn about the noise and aesthetic drawbacks associated with large wind farms.
- Outcome 5c) Visitors will consider the impact of large wind turbines on birds of prey and migrating bird populations in some locations.

A thorough treatment of where we get our electricity and the costs and benefits of each source is presented in a graphic panel titled *"Energy Sources, Energy Choices."* Using this chart, visitors can compare the state of various energy technologies, the long-term prospects for various energy resources, and the pros and cons of using various sources of energy. The theater piece *"Blowin' in the Wind"* draws many of these issues to a personal level as individual characters ask hard questions about wind energy.

Goal 6. Wind Power Live! will examine the economics of wind power.

- Outcome 6a) Visitors will learn why the cost of wind-generated electricity has dropped precipitously over the past decade.
- Outcome 6b) Visitors will understand why wind farms can significantly raise property values by making dual use of the land possible.

In the comparison of energy sources entitled "*Energy Sources, Energy Choices*" visitors can compare some general information about the costs and benefits of wind power vs. other types of renewable and non-renewable energy. Hidden costs of some forms of energy production are included for a realistic comparison.

The "*Ask the Wind Kids*" interactive computer program gives some of the current facts and figures for how much wind-generated electricity costs to produce and how much we can produce with our current technology as well as how great the potential is.

Goal 7. Wind Power Live! will explain some of the limits to wind power as a commercial source of energy.

- Outcome 7a) Visitors will learn about the technological challenges facing the feasibility of expanding the use of wind energy, such as energy storage, but will also be introduced to innovative technological solutions such as compressed-air storage and wind/natural gas hybrid systems.
- Outcome 7b) Visitors will learn about matching intermittent technology to both baseload and peaking demands.

As a sidebar to the "*Energy Sources, Energy Choices*" panel, three of the most commonly cited downsides to wind power are addressed: intermittency, aesthetic concerns, and the danger to birds. In this component as well as in the theater piece "*Blowin' in the Wind*" the state of our current technology and wind's limitations are outlined as well as future possibilities for making widespread use of wind power more feasible. The exhibit, however, does not explicitly cover the topics of specific technological solutions, such as compressed air storage and wind/natural gas hybrid systems, or does it address the issue of trying to match the intermittency of wind power to baseload and peaking demands.

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