SchoolPower ...Naturally

NYSERDA

New York State Energy Research and Development Authority www.nyserda.org

NEW YORK STATE VIRTUAL WIND FARM INSTRUCTOR GUIDELINES

Noble Bliss Wind Park
Wyoming County, NY

PARTICIPATION LEVEL III: GRADES 9-12

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New York State Energy Research and Development Authority www.nyserda.org

New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975. NYSERDA's earliest efforts focused solely on research and development with the goal of reducing the state's petroleum consumption. Subsequent research and development projects focused on topics including environmental effects of energy consumption, development of renewable resources, and advancement of innovative technologies.

NYSERDA strives to facilitate change through the widespread development and use of innovative technologies to improve the state's energy, economic, and environmental wellbeing. NYSERDA is committed to public service, striving to be a model of efficiency and effectiveness, while remaining flexible and responsive to its customers' needs. NYSERDA's programs and services provide a vehicle for the state to work collaboratively with businesses, academia, industry, the federal government, environmental community, public interest groups, and energy market participants. Through these collaborations, NYSERDA seeks to develop a diversified energy supply portfolio, improve market mechanisms, and facilitate the introduction and adoption of advanced technologies that will help New Yorkers plan for and respond to uncertainties in the energy markets.

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New West Technologies is an 8(a) certified small business that provides high quality, cost conscious, multidisciplinary technical support services and management consulting to federal, state, tribal and corporate clients. Focusing on the transportation, building, power and education sectors, our staff includes engineers, scientists, public policy experts, architects, educators, information technologists, and a variety of meeting management, communication, and management support specialists.

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OVERVIEW

These guidelines are designed to assist teachers/mentors in administering the New York State Virtual Wind Farm at the High School Level, which pertains to students in grades 9-12. This guide complements the accompanying **Level III Student Guidelines** and offers suggestions for implementing this activity. Included are instructions regarding the computer application that students are required to use to generate their design, as well as optional research methods and references, submission specifications, student organization methods, and additional information that instructors may choose to relay to students. Contact information is also provided if further assistance is required. All of the supporting documents that instructors should distribute to students participating in the activity are included in the **Student Guidelines** and **Student Concepts Worksheet**.

PURPOSE

This educational resource was developed for the New York State Energy Research and Development Authority's (NYSERDA) *School Power…Naturally*^{SM} Program by New West Technologies, LLC. Its goal is to offer students an introduction to wind turbine technology and the wind farm design process. The activity also provides a platform for teaching renewable energy principles, as well as a seemly intermediary into environmental and ecological studies. The intention is to harness students' ingenuity with turbine concepts in order to increase awareness of wind power generation.

LEARNING OBJECTIVES

Following participation in the NYS Virtual Wind Farm activity, students should:

- be familiar with the factors that influence where a wind farm is located and what natural features would make an ideal site,
- understand how wind tower and turbine variables affect its performance, and
- recognize that there are factors beyond the design of the wind farm and its economic viability that may influence whether it can be built.

KEY LEARNING COMPONENTS

I. *Wind Farm Location*

A. Wind Requirements:

- The better the wind resource, the better the wind turbine output.
- However, there is a maximum wind speed at which the turbines can operate effectively.
- Most sites need an average annual wind speed above approximately 6.5 meters per second (m/s).

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B. Key Land Features:

- Best locations are typically elevated plateaus, ridgelines, open hilltops, near shore, or offshore.
- Spaces should be mostly free of trees and tall buildings in the immediate area.
- It is much more cost efficient to build close to high voltage electric transmission lines and where it is easy to build access roads.

C. Space requirements:

- About one-eighth of a square kilometer (.125km^2) of land is required per turbine.
- Adjacent turbines should be sited in a line perpendicular to the prevailing winds.

II. *Wind Turbine Variables*

- Taller towers will typically reach better wind resources, but if the wind resource does not increase significantly on the vertical axis, the additional cost for a taller tower might not be cost-effective.
- Larger turbines are generally more cost-effective.
- Larger diameter blades can capture more wind resource, but smaller diameters can tolerate higher wind speeds.

III. *Other factors that limit/hinder wind farm development*

- Local zoning laws
- Wildlife habitat disturbance
- Community opinions (Aesthetics: views, noise, misconceptions)

RELEVANT STANDARDS

I. *New York State Education Department: Learning Standards for Mathematics, Science, and Technology*

www.emsc.nysed.gov/ciai/mst/scirg.html

The New York State Education standards that apply to wind energy education are:

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering designs, as appropriate, to pose questions, seek answers, and develop solutions.
Standard 2: Students will access, generate, process, and transfer information using appropriate technologies.
Standard 3: Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.
Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.
Standard 5: Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.
Standard 6: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
Standard 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

II. *No Child Left Behind* www.cbf.org

This activity specifically applies to Section 2201, Part 3 of the original NCLB act which states the need to:

“Bring mathematics and science teachers in elementary schools and secondary schools together with scientists, mathematicians, and engineers to increase the subject matter knowledge of mathematics and science teachers and improve such teachers' teaching skills through the use of sophisticated laboratory equipment and work space, computing facilities, libraries, and other resources that institutions of higher education are better able to provide than the elementary schools and secondary schools.”

The No Child Left Inside amendment to NCLB in 2007 has the most relevance to this activity. The amendment provides various funding opportunities for environmental education programs and reinforces the overall importance of environmental education as a crucial part of primary and secondary education in order to:

“[Produce] graduates who are prepared to address the challenges, adjustments, and opportunities that will be present in the life and the workforce of the 21st century due to threats to human health, economical development, biological diversity, and national security arising from environmental stresses.”

PROCEDURE

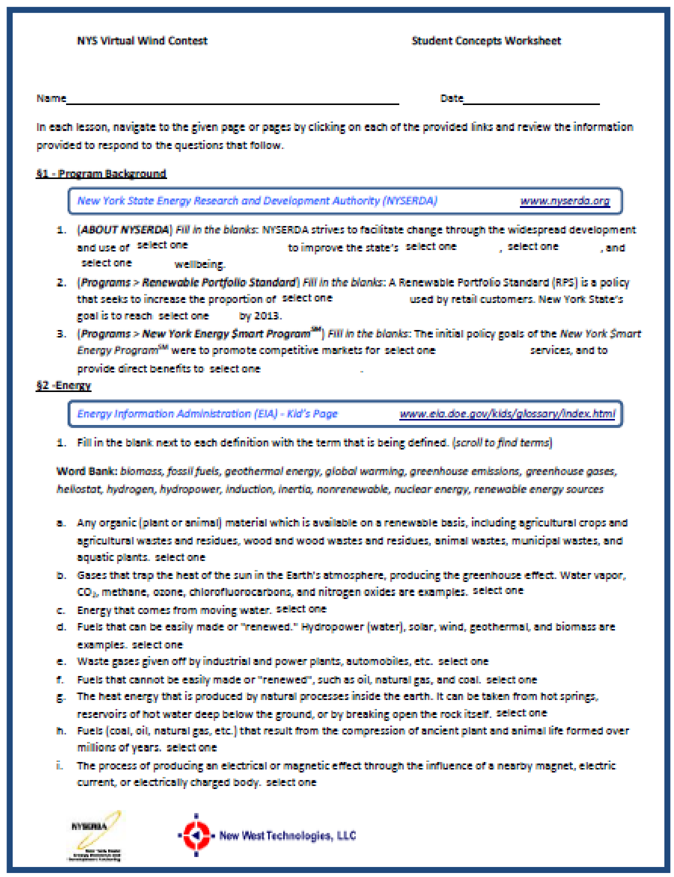
Students will compete to design the most efficient virtual wind farm using a graphical Web-based computer application designed to simulate the actual planning and processes involved in wind farm installations. They will need access to a computer to operate the program via the Internet. Instructors should start by distributing the provided **Student Guidelines** and reviewing all information with participating students. If computers are available, distributing and reviewing these guidelines electronically is encouraged.

I. *Wind Turbine Concepts*

Students should conduct preliminary research in order to gain a better understanding of the basic concepts of wind power generation. Instructors are encouraged to facilitate research using one of the following methods:

Option #1

Distribute the provided **Level III Student Worksheet** that students complete using information and lessons found on the provided Web page links if Internet access is available. If Internet access is not available, students can be given the **Level III Student Worksheet Sources PDF** that can be downloaded from the SPN Virtual Wind Farm Web page. If both the instructor and student have access to the full version of Adobe Acrobat, it is recommended that students use the **Adobe version** of the worksheet, since it offers the most user-friendly format. Otherwise, please distribute the **Excel version** of the worksheet. Instructors can contact the resource coordinator for the **Level III Student Worksheet – Suggested Responses** to manually score the student responses or the **Level III Student Worksheet – Excel Grader** that can be used to automatically score the student's responses regardless of which worksheet format was used. Follow instructions on the first worksheet.


NYS Virtual Wind Contest Student Concepts Worksheet

Name______________________ Date__________

In each lesson, navigate to the given page or pages by clicking on each of the provided links and review the information provided to respond to the questions that follow.

§1 - Program Background

New York State Energy Research and Development Authority (NYSERDA) www.nyserda.org

1. (*ABOUT NYSERDA*) *Fill in the blanks:* NYSERDA strives to facilitate change through the widespread development and use of select one to improve the state's select one , select one , and select one wellbeing.
2. (*Programs > Renewable Portfolio Standard*) *Fill in the blanks*: A Renewable Portfolio Standard (RPS) is a policy that seeks to increase the proportion of select one used by retail customers. New York State's goal is to reach select one by 2013.
3. (*Programs > New York Energy $mart Program*[SM]) *Fill in the blanks*: The initial policy goals of the *New York $mart Energy Program*[SM] were to promote competitive markets for select one services, and to provide direct benefits to select one .

§2 -Energy

Energy Information Administration (EIA) - Kid's Page www.eia.doe.gov/kids/glossary/index.html

1. Fill in the blank next to each definition with the term that is being defined. (*scroll to find terms*)

Word Bank: *biomass, fossil fuels, geothermal energy, global warming, greenhouse emissions, greenhouse gases, heliostat, hydrogen, hydropower, induction, inertia, nonrenewable, nuclear energy, renewable energy sources*

a. Any organic (plant or animal) material which is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants. select one
b. Gases that trap the heat of the sun in the Earth's atmosphere, producing the greenhouse effect. Water vapor, CO_2, methane, ozone, chlorofluorocarbons, and nitrogen oxides are examples. select one
c. Energy that comes from moving water. select one
d. Fuels that can be easily made or "renewed." Hydropower (water), solar, wind, geothermal, and biomass are examples. select one
e. Waste gases given off by industrial and power plants, automobiles, etc. select one
f. Fuels that cannot be easily made or "renewed", such as oil, natural gas, and coal. select one
g. The heat energy that is produced by natural processes inside the earth. It can be taken from hot springs, reservoirs of hot water deep below the ground, or by breaking open the rock itself. select one
h. Fuels (coal, oil, natural gas, etc.) that result from the compression of ancient plant and animal life formed over millions of years. select one
i. The process of producing an electrical or magnetic effect through the influence of a nearby magnet, electric current, or electrically charged body. select one

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Option #2

Review the following suggested resources for informational content and engaging activities that are available for the students as you develop your own approach to introducing wind turbine concepts to suit the needs of your class.

New York State Energy Research and Development Association (NYSERDA)
www.nyserda.org ➢ programs currently offered by NYSERDA ➢ calendar of events i.e. seminars and workshops ➢ several links to other informative sites
www.getenergysmart.org/EnergyEducation/Workshops/WorkshopPresentations.aspx ➢ workshop power points: how and why to integrate energy education at all grade levels
www.powernaturally.org/programs/SchoolPowerNaturally/default.asp?i=9 ➢ NYSERDA's *School Power…Naturally*[SM] (SPN) program Web site ➢ several links to other informative sites
www.powernaturally.org/Programs/Wind/toolkit.asp?i=8 ➢ NYSERDA's *Power…Naturally*[SM] program Web site – Wind Energy Tool Kit ➢ provides extensive information on the various aspects of wind energy development arranged by topic into convenient information guides
windexplorer.awstruewind.com/NewYork/NewYork.htm The New York Wind Resource Explorer (WRE) was developed by AWS Truewind LLC for NYSERDA. Included are maps of mean annual wind speed at 30, 50, 70 and 100 meters above effective ground level, and an additional map depicting wind power density at 50 meters above effective ground level. The New York WRE presents these wind maps with supporting spatial data as an interactive map interface enabling users to view, query and print wind resource maps and reports.

Northeast Sustainable Energy Associations (NESEA) – Wind Wisdom for SPN[SM]
www.nesea.org/k-12/solarsailsnewyork As part of NESEA's Solar Sails New York program, NESEA is providing free wind energy education workshops to teachers and non-formal educators. At the workshop educators will receive engaging, hands-on science and engineering activities that support NYS Learning Standards and Core Curriculum; as well as a free energy education kit and support materials for your classroom, center, or institution. The *Wind Wisdom for School Power…Naturally* unit includes the following topics: ➢ What is Wind? ➢ The History of Wind Turbine Development and Industry ➢ Wind Energy Generation Experiments ➢ Design and Siting Experiments ➢ Wind Turbines and Farms in New York State ➢ Wind Energy Career Options

U.S. Department of Energy (DOE) – Energy Efficiency and Renewable Energy (EERE)

www1.eere.energy.gov/windandhydro/wind_basics.html

This site includes information on the following topics and also provides links to several other useful resources:

- How Wind Turbines Work
- Advantages and Disadvantages of its Use
- Wind Energy Use Throughout History
- U.S. Wind Energy Resource Potential
- Current Research and Development

www.apps1.eere.energy.gov/education/lessonplans/plan.cfm/lpid=289

This site includes instructions on giving lessons for the following:

- Calculating Wind Power Potential in Your City
- Designing and Constructing a Wind Vane and an Anemometer
- Determining Lift and Drag Forces of Various Designs
- What Propeller Size and Design is the Most Efficient in Producing Electricity?
- What is the Most Efficient Spacing of Wind Turbines for "Farming" the Wind?
- What is the Most Capable Area in your Community for Using Wind as an Energy Source?
- Is Solar, Wind, or Solar and Wind the Best Method to Generate Electricity?

National Renewable Energy Laboratory (NREL)

www.nrel.gov/learning/re_wind.html

This site provides current events in the world of renewable energy, lessons on renewable energy basics including a section on wind power and its applications, and links to several additional resources.

Energy Information Administration (EIA) – Kid's Page

http://tonto.eia.doe.gov/kids

This is a complete energy concepts site that provides several educational games and activities, a comprehensive glossary, an extensive Teacher's Guide and list of lesson plans arranged by grade level, links to several other useful resources, and lessons on the following topics:

- What is Energy?
- Energy Sources
- Using and Saving Energy
- History of Energy

General Electric (GE) Wind Energy Curriculum

www.gepower.com/businesses/ge_wind_energy/en/kids_teachers/index.htm

This site includes discussion points to get students thinking about what wind power is and its benefits. Also included are worksheets for quick lessons about wind power basics.

Kid Wind

www.kidwind.org/lessons/SFScienceFair.html

This site provides instructions for how to create your own model wind turbine. (See: Intermediate Turbine Instructions) This site also breaks down the variables that must be examined in determining what type of wind turbine is to be used. Also included are lessons on:

- Turbine and Blade Design
- Power Output
- Wind Meteorology
- Generators and Motors

www.kidwind.org/PDFs/SUPPORT_Math_Swept%20Area.pdf
This *Wind Energy Math Calculations* page provides information about the *wind swept area* of a turbine rotor, as well as the *Power in the Wind* equation and a few sample problems.

Danish Wind Industry Association

www.talentfactory.dk/en/kids/index.htm
This is a link to the "Wind with Miller" Wind Turbine Simulator where students are given four different wind turbine options and are asked to do the following:

- calculate the minimum wind speed it takes to get the turbine turning
- calculate the maximum wind speed at which the turbine can safely operate
- calculate the amount of power generated by the wind turbine at given wind speeds
- calculate the maximum power output of the turbine
- determine the influence of turbine height on wind speed and power generation
- determine the environment that has the best conditions for wind (Roughness Class)
- put all of these elements together to create the most efficient wind farm

American Wind Energy Association (AWEA)

www.awea.org
This site provides current events regarding the wind industry, as well as a *Wind Web Tutorial* including the following topics:

- Wind Energy Basics
- Wind Energy Costs
- Wind Energy's Potential
- Wind Energy and the Economy
- Wind Energy and the Environment
- Offshore Wind
- Wind Energy Statistics
- Small Wind Energy Systems
- Wind Energy Policy Issues
- Wind Energy Resource Guide

Alliance for Clean Energy New York, Inc. (ACENY)

www.aceny.org/clean-technologies/wind-power.cfm
This site provides the most comprehensive listing of the locations and capacities of currently operational wind farms in New York State under *Wind Power Facilities in New York*, as well as discussion of the following topics:

- Wind Power
- Overview of Wind Power in New York
- Wind Myths Corrected
- Wind and Agriculture
- Small Scale Wind
- New York Offshore Wind

Wind Energy Resource Atlas of the United States

rredc.nrel.gov/wind/pubs/atlas/maps.html
This site provides links to an extensive list of wind resource maps that exhibit the average wind resources across the United States, including maps that depict the annual and seasonal averages by means of a color scale.

Zero-Footprint Calculator

www.zerofootprintkids.com/kids_home.aspx
This is a link to a student-friendly carbon footprint calculator. Students are asked a series of questions about their daily energy consumption and are given their total ecological footprint score in the form of a pie chart, a numerical score, and in terms of how many earths it would take to support the student's daily decisions. The calculator also compares the student's score to the average score of a given country.

II. *Creating the Virtual Wind Farm*

Students must use the Virtual Wind Farm Tool to design their own virtual wind farm adhering to the **Specifications** and following the method outlined in the **Student Guidelines**. Students should be able to get acquainted with the program and create a virtual wind farm in approximately one hour. The optimization of the design may require 2-4 additional hours as they determine the location with the greatest wind resource and discover the turbine attributes that contribute to a lower cost to energy ratio.

If the **Student Guidelines** are being distributed electronically, students may navigate to the Virtual Wind Farm Tool by clicking on the URL link provided. If a printed version of the **Student Guidelines** is distributed, students may enter the URL address into the navigation bar on the Internet browser.

www.powernaturally.org/Programs/SchoolPowerNaturally/VirtualWindFarm.asp

Full class participation is encouraged, but this may also be completed as an extra credit assignment. Instructors may choose to organize students using one of the following methods:

1. Request that students work individually or in groups of 2-4 and conduct a preliminary activity within your class in order to determine the best design.
2. Create a design that is the result of a collaborative effort from all participating students.

To limit the amount of area that the students investigate for wind potential, it is recommended that a particular county location be specified. When conducting this activity multiple times, changing the county location is a way to add variety. Note that the virtual wind tool will not be able to validate this specification, so it will need to be checked manually.

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III. *Development of the Design Synopsis*

Students should develop a brief synopsis of the logic behind their design decisions and include any additional details of the proposed wind farm layout as outlined in the **Student Guidelines**. Instructors can encourage students to use graphs, diagrams, a detailed map, and/or any other visuals that may support their reasoning. Please ensure that the students address the questions mentioned in the **Student Guidelines** and limit the synopsis (including any graphs, figures, or maps) to four pages. Regarding the development of synopses, instructors may choose to organize students with one of the following methods:

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1. Request that each student or group develop a synopsis for their wind farm design that corresponds with the wind farm design that they created.
2. Determine the best wind farm design within the class, then ask either the winning team alone or all participating students collectively to develop a synopsis based on that design.

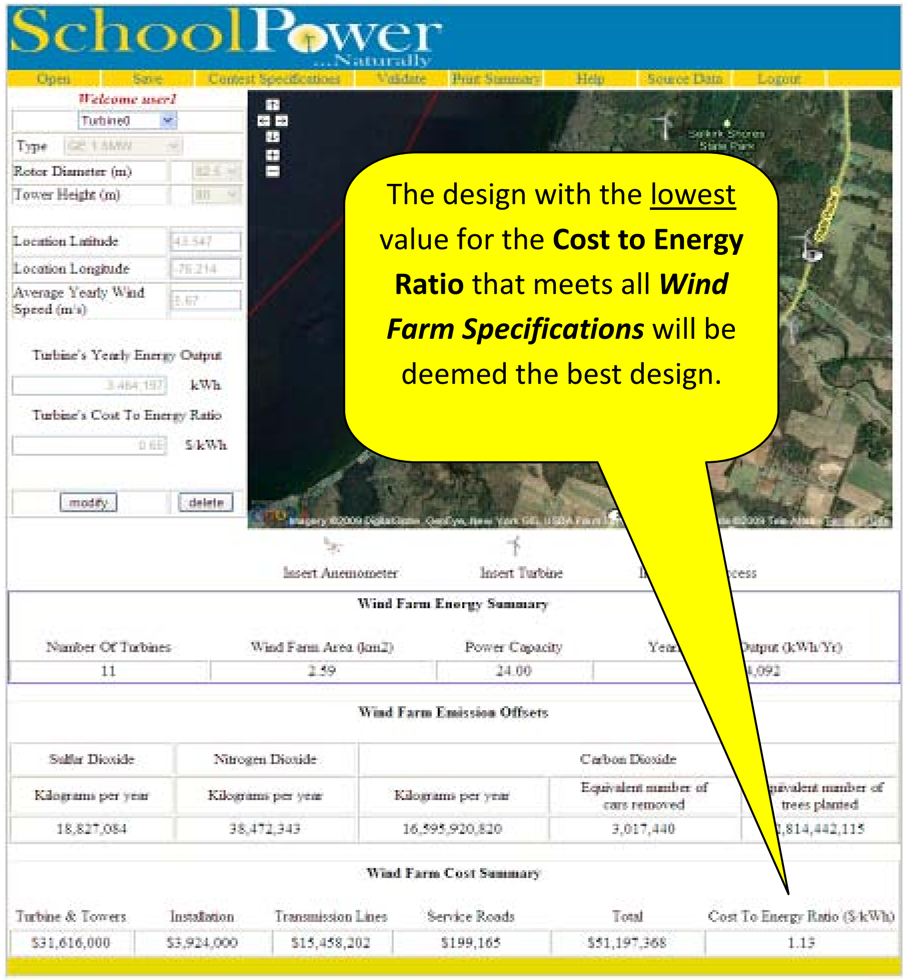
IV. *Development of an Outreach Component*

Students should also complete an outreach assignment that aims to inform the community about the benefits of utilizing wind energy as outlined in the **Student Guidelines**. This could be in the form of a poster, Web site, speech or presentation, letter to elected officials, etc. Instructors can encourage students to be imaginative and resourceful. To the extent possible, they should make creative and effective use of visuals and communication tools in order to accurately convey information in a compelling way. Regarding the development of the outreach component, instructors may choose to organize students using one of the following methods:

1. Request that each student or group develop an outreach component and select the one that is best in the class.
2. Request that all participating students work collectively to develop an outreach component.

EVALUATION

The virtual wind farm components can be scored out of a possible 100 points, which is calculated by adding the points from the Wind Farm Design (50 possible points), Design Synopsis (25 possible points), and Outreach Component (25 possible points).



I. *Wind Farm Design* (50 points)

The criteria used to evaluate the wind farm design is the system's **COST TO ENERGY RATIO** indicated on the Virtual Wind Farm Tool Output (as illustrated on the sample screenshot below) provided all **Wind Farm Specifications** (max power capacity, location, etc.) have been met. Designs will be awarded points based on how their design compares with the entry with the lowest cost to energy ratio.

II. *Design Synopsis* (25 points)

The provided **Design Synopsis Evaluation Rubric** in the **Student Guidelines** outlines the evaluation criteria and corresponding point system that can be used to score the design synopsis to which a maximum of 25 points may be given.

III. *Outreach Component* (25 points)

The provided **Outreach Component Evaluation Rubric** in the **Student Guidelines** outlines the evaluation criteria and corresponding point system that can be used to score the outreach component of this project to which a maximum of 25 points may be given.

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