CELF
ENVIRONMENTAL LITERACY

Subject/course: Technology **Grade level(s):** 8

Unit title: Wind Turbine Towers

UNIT/LESSON SUMMARY

This is a 6 week unit of instruction for the Grade 8 Technology classroom. It was designed to teach students the design process through a lens of sustainability. The IB design cycle is used.

Students are challenged to design and build a functioning model wind turbine and measure their electrical outputs. They will be introduced to sustainability and systems thinking. They are challenged to research and work through several labs that take a look at forces acting on a structure, how wind turbines generate electricity, how geometry affects strength, and some of the important terminology associated with this construction. They will apply their knowledge while completing the turbine tower design challenge to create a tower to support their turbine and resist naturally occurring forces such as wind, weight of snow, etc…

After completing the labs, students will design and build their models. The outputs of the turbines will be recorded and graphed with others' data. Students will analyze their data to further explore the affects of design.

Stage 1 - Desired Results

Established Goal(s) :
NY State Standards addressed by the lesson (Include minimum of two state frameworks goals for this subject and grade level that this lesson aligns to):

NYSED Standard 5.1 Engineering Design

NYSED Standard 5.2 Tools, Resources and Technological Processes

NYSED Standard 5.3 Computer Technology

NYSED Standard 5.7 Management of Technology

National Education for Sustainability Standards addressed by the lesson (Include minimum of two EfS standards that this lesson aligns to)**:**

EfS Standard 1 – Students understand and are able to apply the basic concepts and principles of sustainability.

EfS Standard 2 – Students recognize the concept of sustainability as a dynamic condition characterized by the interdependency among ecological, economic, and social systems and how these interconnected systems affect individual and societal well-being. They develop an understanding of the human connection to and interdependence with the natural world.

Name: Elyjah Perry School: Louis M Klein Middle School

Outcomes (How can sustainability education help your students learn this?)	
Enduring Understandings: (what understandings are desired) *Students will understand that…* • Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact • Engineering design is an iterative process involving modeling and optimization used to develop technological solutions to problems within given constraints. • Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity, sustainability and knowledge. • Project management is essential to ensuring that technological endeavors are profitable and that products and systems are sustainable, high quality, built safely, on schedule, and within budget.	**Essential Questions:** (what essential questions will be considered?) • How should sustainability influence design and construction? • What can I do to help the sustainability movement moving forward? • How does the designed world impact ecological, economic, and social systems?
Students will know… • The iterative steps of the IB design cycle • The relationship between geometry, structure, and strength • The forces acting on a structure, and how the structure can sustain them • The relationship between blade size and shape and its ability to produce energy	*Students will be able to…* • locate and utilize a range of printed, electronic, and human information resources to obtain ideas • consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal • develop plans, including drawings with measurements and details of construction, and construct a model of their solution, exhibiting a degree of craftsmanship • use hand tools to change materials into new forms through separating and combining processes • use computer software to draw and dimension prototypical designs • manage time and financial resources given limited amounts of material and time
Stage 2 – Assessment Evidence	
Performance Task(s): (what evidence will show that students understand?): • Participation in class discussion • Sketching systems diagrams • Blade design sketches • Truss design sketches • Selection/Use/Conservation of Materials	**Other evidence:** (quizzes, tests, prompts, observations, dialogues, work samples): • Forces Lab • Shapes Lab • Structural Engineering worksheet • Structural Engineering quiz • Wind Energy Lab • Turbine Tower Design Challenge (rubric)

Stage 3 – Learning Plan

Learning Activities: (what will students do and what will you, the teacher do, to prepare the students to achieve the desired outcomes)?

I. Introduction to Wind Turbine Tower design challenge.
Sustainability discussion:
- What is Sustainability?
- Why practice sustainable design?
- Who is affected?
- The "commons" (students will create a Venn diagram from an idea salad)

II. Systems: inputs, processes, outputs, and feedback
- Discussion
- Students sketch diagrams of basic loop
- Students sketch life cycle of a pencil

III. Structural Engineering worksheet*

IV. Forces Lab*

V. Shapes Lab*

VI. Structural Engineering Quiz*

VII. Wind Energy Lab*

VIII. Turbine Tower Design Challenge*

*See attached document files.

Resources: What **community** resources can be used in planning and teaching (websites, individual speakers, organizations, resources)? Please hyperlink all websites to the appropriate URL.

http://www1.eere.energy.gov/wind/wind_animation.html

http://www.nywind.com/

http://www.pbs.org/wgbh/buildingbig/index.html

http://www.horizonwind.com/projects/whatwevedone/mapleridge/

http://www.nyserda.ny.gov/en/Program-Areas/Energy-Efficiency-and-Renewable-Programs/Economic-Recovery.aspx

Sameshima, Wilbur A., Energy in the Wind: Exploring Basic Electrical Concepts by Modeling Wind Turbines. 2003.

http://www.nrel.gov/learning/re_wind.html/

Stage 4 – Addendum

The file names for all elements of your Unit/Lesson.

Shapes Lab.doc
Forces Lab.doc
Tower Engineering Worksheet.doc
Structural Engineering Assessment.doc
Wind Energy Lab. doc
Wind Turbine Tower Design Challenge. doc
Design Brief. doc
DB Rubric.xls
Final Product Rubric.xls
Teachers_guide_wind.pdf

Louis M. Klein Middle School
Department of Technology – Mr. Perry

Structural Shapes Lab

Name: _____ **Period: _____**

The shape of a structure greatly affects how strong it is. Rectangles, arches, and triangles are the most common shapes used to build big structures. Complete the questions below to learn more about these shapes. Work through the lab at http://www.pbs.org/wgbh/buildingbig/lab/shapes.html or search "PBS Shapes Lab" in the Google search engine.

Drag the slider to "1." Notice the elephants that appeared on the shapes.

1. What force do the red arrows represent? _____
2. What force is represented by the blue arrows? _____
3. Which shape is only in compression? _____

Drag the slider to the "3."

4. Which shape is the weakest? _____
5. Which shape likes to be pushed and squeezed? _____

Drag the slider to the "6."

6. Which is the strongest shape? _____
7. Why? _____

_____

Return the slider to zero.

Choose the rectangle.

8. Push It! What shape does the rectangle take when you pushed on it? _____
9. Strengthen It! What is put in the middle of the rectangle? _____

Click on "Compare Strength."

10. Now select the arch and Push It! The sides of the arch go _____.
11. Strengthen It! What are the external supports called? _____

Click on "Compare Strength."

12. Select the triangle and Push It! What is the weakest part of a triangle? _____
13. Try the Strongest Point! Push It! What side of the triangle is in tension? _____

Louis M. Klein Middle School
Department of Technology – Mr. Perry

Structural Forces Lab

Name: _____ **Period: _____**

Forces act on big structures in many ways. This lab simplifies the real-life forces and actions that affect structures. Follow the link to the Forces Lab at http://www.pbs.org/wgbh/buildingbig/lab/forces.html or search "PBS Forces Lab" in the Google search engine.

Click on one of the actions on the left to explore the forces at work and to see real-life examples.

Choose Squeezing.
1. What is the name of this force? _____

2. What happens to a material when this force is applied? _____

3. *See It In Real Life!* The lower _____ of a skyscraper are squeezed by the heavy weight above them.

Choose Stretching.
4. What is the name of this force? _____

5. What happens to a material when this force is applied? _____

6. *See It In Real Life!* The weight of the _____ and all the cars traveling on it pull on the vertical cables in this suspension bridge.

Choose Bending.
7. When a straight material becomes _____, one side squeezes together and the other side stretches apart. This action is called bending.

8/9. The top side of the metal bar is pulled apart in _____, and the bottom side is squeezed together in _____. This combination of opposite forces produces an action called bending.

Choose Sliding.
10. What is the name of this force? _____

11. What happens to a material when this force is applied? _____

12. *See It In Real Life!* During an _____, parts of this roadway slid in opposite directions.

Choose Twisting.
13. What is the name of this force? _____

14. What happens to a material when this force is applied? _____
15. See It In Real Life! In 1940, the _____, twisted violently in strong winds and collapsed. It was this twisting force that tore the bridge in half.

Louis M. Klein Middle School

Department of Technology – Mr. Perry

Wind Energy Lab

Name: _____ Date: _____ Period: _____

Read the page at http://science.howstuffworks.com/environmental/green-science/wind-power2.htm **to answer the following questions:**

There are two primary Wind-power designs are _____ and _____.

The more commonly used design is _____.

The Darrieus turbine is an example of a _____ axis wind turbine.

Explain the following components:

Rotor blades-

Shaft-

Nacelle-

Gearbox-

Generator-

Electronic control unit-

Yaw controller-

Brakes-

Tower-

Electrical equipment-

Take a look at the process of generating electricity from wind and delivering that electricity to people who need it. Follow the links through "How Wind Power Works," select *next* from the bottom right of the picture.

The energy in the wind is converted to rotational motion by the _____.

When the blades turn, the rotor turns a _____, which transfers the motion into the _____.

The slowly rotating shaft enters a _____ that greatly increases the rotational shaft speed.

The output shaft is connected to a generator that converts the rotational movement into _____ at a medium voltage (hundreds of volts).

The electricity flows down heavy electric cables inside the _____ to a transformer, which increases the _____ of the electric power to the distribution voltage (thousands of volts).

The distribution-voltage power flows through underground lines to a _____ point where the power may be combined with other turbines.

The electricity may be _____to farms, residences, and towns.

The electricity may also be sent to a _____ where the voltage is increased to transmission-voltage power (hundreds of thousands of volts) and sent through above-ground transmission lines to distant cities and factories.

Louis M. Klein Middle School
Department of Technology – Mr. Perry

Wind Turbine Towers Design Challenge

Introduction:
A local land developer is looking for an attractive design for the towers in her new Wind Energy Farm. She has asked for models of the designs so she can choose the one that most suits her style. They will have to be very attractive as the local people are resistant to the idea of a wind farm in their community.

Task:
Before you can build a model, you must understand some of the engineering that goes into these types of towers. You will work in teams of two to research, design, and build a model turbine tower.

Process:
Each student will have two class periods to complete the three lab worksheets, the "Tower Engineering" worksheet, the Forces Lab, and the Shapes Lab. Upon completion of your research (up to Step 5 in Design Brief), as a team you will create construction drawings as plans for the model towers. The teacher will supply each team with 10 - 36" inch lengths of 1/8" x 1/8" balsa and glue. Your designs should be efficient and well thought out. In order for your design to win the job, it should be attractive and capable of holding the turbine high enough to catch a lot of wind. It also needs to be sturdy to withstand the wind and other naturally occurring forces.

Resources:
Use the links provided below to research wind turbine tower development. Feel free to use other websites, but you **must** provide the address of all sites you find information from!

Evaluation:
You will be evaluated on the completion of the worksheets (50 pts each), the design brief (100 pts), and the construction of the model towers (final product – 100 pts).

Conclusion:
You are to complete a brief report for your client that discusses what parts of your model worked and which did not. Included should be any changes you would make to insure a quality wind turbine tower. Please be sure to tell me which websites were most helpful! This should be done in your design brief - Step 6.

Online Resources:

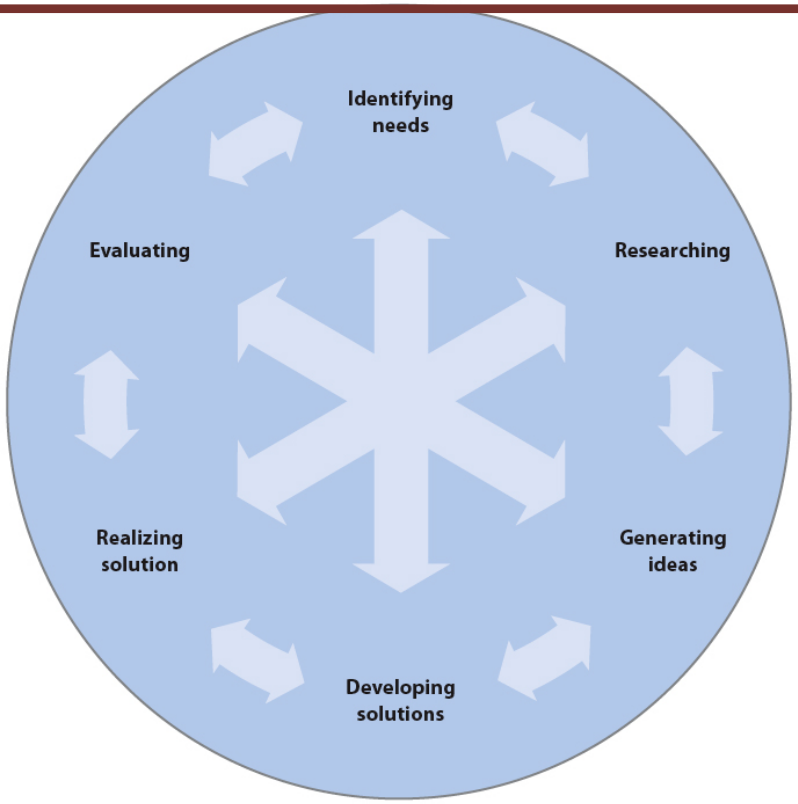
Link	Rating
Skyscraper Basics	✩✩✩✩✩
Illustrated Architecture Dictionary	✩✩✩✩
Building Big! Glossary	✩✩✩✩✩
How does a Wind Turbine Work?	✩✩✩✩
The Great Buildings Collection	✩✩✩✩
Shapes Lab	✩✩✩✩✩

Harrison Central School District

Department of Technology – Design Brief

THE DESIGN CHALLENGE: (Project Title here)

Designers: (All group members)



1. IDENTIFYING NEEDS

- **Write a problem statement. What are you being challenged to do?**

- **Specifications & Constraints:**

2. RESEARCHING (BRAINSTORM)

What questions do you need to ask in order to design the best solution? List them.

1.

2.

3.

Research the answers to the questions listed above. Write your answers below.

1.

2.

3.

What sources of information did you use for your research? Cite your sources below.
Ask.com and Wikipedia are not acceptable sources.

1.

2.

3.

3. GENERATING IDEAS

Describe four possible solutions to the problem identified in Step 1. Remember to consider the specifications and constraints.

- Solution: What about this idea meets your specs and constraints?
- Strengths: What are the possible positive results of this idea? Does it have a healthy impact on society? Is it a sustainable solution?
- Weaknesses: What could be a negative result of this idea? Will it negatively affect society?

IDEA #1

Sketch

Solution:

Strengths:

Weaknesses:

Source:

IDEA #2

Sketch

Solution:

Strengths:

Weaknesses:

Source:

IDEA #3

Sketch

Solution:

Strengths:

Weaknesses:

Source:

IDEA #4

Sketch

Solution:

Strengths:

Weaknesses:

Source:

4. DEVELOPING SOLUTIONS

What ideas will you use in your design? Why?

What variables affect your design and why? A variable is one of the factors that can influence the performance. (Weight, shape, location…)

1.

2.

3.

Create a drawing of your final idea. Your design should include accurate measurements and be to scale. Attach the drawings to the back of your design brief.

What tradeoffs did you make in choosing your final idea?

5. REALIZING SOLUTION (BUILD IT!)

What resources have you used or will you use, including during the design cycle? Fill in the 7 resources below.

TIME: (Start Date until End Dates)

INFORMATION: See Design Brief! This is its whole purpose!

CAPITAL: (How much do things cost?)

TOOLS/MACHINES: (Which ones?)

ENERGY: (What types?)

MATERIALS: (Which ones?)

PEOPLE: (Who?)

6. EVALUATING

Does the product meet the constraints identified in Step 1? How?

What problems did you encounter during the Design Process? State the problems below.

If you were to redesign and improve your idea, what changes would you make? Why?

What are the tradeoffs of your improved design?

Design Brief Rubric				
	Unsatisfactory	**Basic**	**Proficient**	**Distinguished**
Identifying needs (10 points) _____	*Missing specs and constraints. Bullet format used. (0-3 pts)*	*Includes most specs and constraints and is written in paragraph form. (4-6 pts)*	*Problem statement includes all specs and constraints. It is written in paragraph form and has been checked for proper grammar and spelling. (7-8 pts)*	*Problem statement is clearly thought out and well written. All specifications and constraints have been identified. (9-10 pts)*
Researching (10 points) _____	*Missing questions and/or answers. Sources have not been cited.(0-3 pts)*	*Questions or Answers are present and somewhat thought out. Sources have not been cited. (4-6 pts)*	*Questions and Answers are thoughtful. Hyperlinks to the sources are given. (7-8 pts)*	*Questions are well thought out. Answers have been found and thought through and sources have been cited. (9-10 pts)*
Generating ideas (40 points) _____	*Ideas or justifications are missing. Pictures and sketches are missing their sources.(0-15 pts)*	*Missing ideas or justifications. All pictures are used and sources are hyperlinked.(16 -24 pts)*	*Three or four ideas are present. The ideas are described as a solution. Strengths and weaknesses are present, bullet format was used. Sources of sketches and pictures are identified. (25-34 pts)*	*Four ideas are present. The ideas are described as a solution to the problem identified in Step 1. Strengths and weaknesses have been carefully thought through and are written in full sentences. Source of sketch or picture is identified. (35-40 pts)*
Developing solutions (20 points) _____	*Missing variables, drawing, and/or tradeoffs. (0-9)*	*Variables are listed. Drawing is done. Tradeoffs listed in bullet format. (10-14 pts)*	*Variables are listed. Optimal solution is being thought over. Tradeoffs are present. Drawing is done including dimensions. (15-17 pts)*	*Variables and their affects are clear and well written. All ideas are thought out and presented in paragraph form.Tradeoffs are clearly presented.Drawings are neatly done including dimensions. (18-20 pts)*
Realizing Solution (10 points) _____	*Missing several resources used. Student was disrespectful toward tools and materials. Poor use of class time. (0-3 pts)*	*Some resources have been identified. Student used tools, materials, and time responsibly. (4-6 pts)*	*Most resources have been identified. Student showed respect for all tools and materials.(7-8 pts)*	*All resources used have been identified. Class time is used wisely during construction. Student showed respect for all tools and materials. (9-10 pts)*
Evaluating (10 points) _____	*Missing answers. No redesign thoughts are present. (0-3 pts)*	*Questions are answered, redesign not thought through. (4-6 pts)*	*Questions are answered in complete sentences. Answers show some thought regarding the final product. Redesign is not thorough.(7-8 pts)*	*All questions answered in complete sentences. Answers are well thought out and responses are clear. Redesign clearly thought through. (9-10 pts)*

Wind Turbine Tower Rubric				
	Unsatisfactory	**Basic**	**Proficient**	**Distinguished**
Use of Materials _____ /20	*Did not budget materials well. More material was needed to complete the tower than was in the budget. (0-5 pts)*	*Tower is within budget. No materials left. (6-10 pts)*	*All materials used well. Some scrap left. Tower is within budget.(11-15 pts)*	*Wise use of materials. Tower completed within budget. Some materials left over.(16-20 pts)*
Craftsmanship _____ /20	*Joinery is sloppy. Glue is very visible in most places. Sloppy overall appearance. (0-5 pts)*	*Joinery is not clean cut. Glue is very visible in some spots. (6-10 pts)*	*Good quality of construction. Joints are mostly cut well and glue was applied neatly. (11-15 pts)*	*High quality of construction. All joints were cut well and glue was applied in a neat fashion. (16-20 pts)*
Aesthetics _____ /20	*Tower leaves something to be desired. Sloppy ideas, repetitive of others ideas. (0-5 pts)*	*Tower looks good. Design ideas not unique but well done. (6 -10 pts)*	*Tower is well designed. Some uniqueness. (11-15 pts)*	*Tower is aesthetically pleasing. Unique qualities are present. Effort is seen in the design. (16-20 pts)*
Turbine Performance _____ /20	*Electrical output not generated or inconsistent. (0-5 pts)*	*Minimal electrical output generated. (6 -10 pts)*	*Average electrical output generated. (11-15 pts)*	*Maximum electrical output generated. (16-20 pts)*
Strength of Design _____ /20	*Force of fan knocks tower over. Doesn't hold turbine. And/or tower doesn't stand on its own.(0-5 pts)*	*Resists the force of the fan and the weight of the turbine. Structure stands but is not balanced.(6 -10 pts)*	*Resists the force of the fan and the weight of the turbine. Structure stands but is not well balanced. (11-15 pts)*	*Resists the force of the fan, the weight of the turbine, no structural issues present. (16-20 pts)*