 **NSF Sustainable Energy Grant RET Lesson** 

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| **Lesson Title:** Build-a-Turbine activity | **Grade Level/Subject:**  5th – 12th Grade, science |
| **Maximum # of Students:** Students in Classroom | **Total Time Required**: 5-8 class periods |
| **Prior Knowledge Needed:** Understanding of transfer of energy. Understanding of conservation of energy. Understanding of how magnets and rotation can be used to generate electrical current. Safety training in all required equipment.  |

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| **Materials and Preparation:**

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| * Multimeter
* Wire clips
* Mini generators
* Motors
* 3D printed hub
* LED lights
* 1-2 fans
* PVC pipe
* Dowel rods
* Balsa wood
* Cardboard
* Newspaper
* Construction paper
* Cardstock
* Wax paper
* Foil,
* Craft foam squares
* Liquid glue
* Duct tape
* Scissors
* Ruler
* Paint brush.

Underlined materials can be substituted or removed from the project. | * Propellers
* Tubing
* Solar panels (2V 400mA)
* Multi-meters
* Assorted LEDs
* Solar motors
* Pairs of clamp wires
* Wire strippers
* Protractors
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| **Performance Objectives/Learning Targets:*** Students will discover and learn how sustainable energy works through solar and wind activities
* Students will learn why some places may need different types of renewable energy sources
* Students will learn about transfer of energy
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| **Standards:** |
| **Lesson Procedure** |
| **Before:** | * Assign students into groups of 3-4
* Print one hub for each group
* Allow students to individually work on the pre-assessment worksheet
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| **During:** | **Allow students to test their windmills at various locations outside the school****Ask probing questions:**Ex. When does the LED light shine the brightest?When does the LED light turn off?What spots have the most consistent wind?What are some similar characteristics of those spots?**Provide Students the following instructions:** (**NOTE:** Older students may not need instructions and should be allowed to determine materials and procedures for themselves)1. **Construct the Blades**:
	* Cut balsa wood into blade shapes using scissors.
	* Attach the blades to the hub using liquid glue or duct tape. Ensure they are evenly spaced.
2. **Assemble the Turbine Body**:
	* Use PVC pipe as the body of the turbine. Cut it to the desired length using a saw or scissors.
	* Attach the hub and blades assembly to one end of the PVC pipe securely using duct tape or glue.
3. **Attach the Mini Generators/Motors**:
	* Fix the mini generators/motors to the opposite end of the PVC pipe from the blades using duct tape or glue.
4. **Connect Wiring**:
	* Use wire clips to connect the mini generators/motors to the LED lights. Make sure the wiring is secure and insulated.
	* Use the multimeter to test the connections and ensure they are functioning properly.
5. **Enhance Stability and Appearance**:
	* Use cardboard or construction paper to create a base for the turbine to stand on.
	* Use duct tape or glue to attach the PVC pipe to the base securely.
	* Decorate the turbine body using paint, foil, craft foam squares, or any other decorative materials available.
6. **Test the Wind Turbine**:
	* Set up the wind turbine in an area with sufficient wind or use a fan to generate airflow.
	* Observe the rotation of the blades and the generation of electricity by the mini generators/motors.
	* Verify that the LED lights illuminate when the turbine is spinning.
7. **Optional Enhancements**:
	* Add a switch to control the LED lights.
	* Experiment with different blade designs or materials for improved efficiency.
	* Use wax paper or feathers to streamline the blades for better performance.
8. **Final Touches**:
	* Secure any loose components with additional duct tape or glue.
	* Ensure all connections are secure and insulated to prevent electrical hazards.

By following these steps, you can create a small-scale functional wind turbine using the provided resources. Adjustments and enhancements can be made based on available materials and personal preferences. |
| **After:** | * Give students the post-assessment work sheet
* Have an in-class discussion
* Reiterate probing questions from during the activity
* Allow students to keep their windmills and dispose of extra materials
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| **5E Model:** *Engage, Explore, Explain, Evaluate, Elaborate*Engage: Pre-assessment worksheetExplore: probing questions throughout activityExplain: In-class discussion with reiteration of contentEvaluate: Post assessment worksheetElaborate: Sharing area characteristics that facilitate energy production and post activity discussion |

*Worksheets Attached below:*

**Pre-Assessment worksheet:**

Title: Wind Energy Pre-Assessment Worksheet

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Instructions: Please answer the following questions to the best of your ability. This pre-assessment will help gauge your current understanding of wind energy concepts before you engage in building a small-scale windmill project.

1. Define transfer of energy in your own words:
2. Explain the concept of conservation of energy:
3. How can magnets and rotation be used to generate electrical current in the context of wind energy?
4. Describe what happens when wind energy is converted into electrical energy using a wind turbine:
5. Name two factors that can affect the efficiency of a wind turbine:
6. True or False: Wind energy is a renewable source of energy because wind is constantly replenished on Earth.
7. Describe two advantages of using wind energy as a power source:
8. Describe two disadvantages or challenges associated with using wind energy:
9. Sketch a simple diagram showing how a wind turbine converts wind energy into electrical energy. Label the key components involved.
10. List three real-world applications or uses of wind energy other than generating electricity:
11. Provide an example of a country or region where wind energy is extensively used for power generation. Briefly explain why wind energy is suitable in that location.
12. Why is it important to consider environmental impacts when implementing wind energy projects?

Please answer all questions independently and to the best of your ability. There are no right or wrong answers. Your responses will help guide our discussions and activities as we explore wind energy further in class.

**Post Assessment Worksheet**

Title: Wind Energy Post-Assessment Worksheet

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Instructions: Please answer the following questions based on your experience building and testing your small-scale wind turbine. Reflect on what you have learned throughout the process. This post-assessment will help assess your understanding of wind energy concepts after engaging in the hands-on activity.

1. Describe the process you followed to build your small-scale wind turbine. Include any materials used and key steps involved:
2. Reflecting on your construction process, explain how the design of your wind turbine was influenced by concepts such as transfer of energy and conservation of energy:
3. Did your wind turbine successfully generate electrical current when tested? If yes, describe the testing process and the amount of electrical current produced. If not, discuss any challenges faced and possible reasons for the turbine's inefficiency:
4. How did magnets and rotation play a role in generating electrical current in your wind turbine?
5. Compare the efficiency of your wind turbine in converting wind energy into electrical energy with your initial expectations. Were there any surprises or unexpected outcomes?
6. Describe any modifications or improvements you made to your wind turbine design during the testing phase. Explain the reasons behind these changes:
7. Reflect on the real-world applications of wind energy discussed in class. How does your understanding of wind energy now compare to before you built and tested your wind turbine?
8. Discuss any environmental considerations that arose during the construction and testing of your wind turbine. How did you address these considerations in your design or testing process?
9. Based on your experience with this project, what are some key factors to consider when designing an efficient wind turbine?
10. How do you think small-scale wind turbines, like the one you built, contribute to the larger conversation about renewable energy and sustainability?

Please answer all questions based on your personal experience and reflections from the wind turbine project. Your responses will help evaluate your understanding of wind energy concepts and their practical applications. There are no right or wrong answers.