

Western Engineering Outreach

Whirling Windmills

Grades 6-8

Meet Today's ENG HERO!



Clare Robinson - Associate Professor with Western Engineering

Dr. Robinson is a leading researcher at RESTORE (Research for Subsurface Transport and Remediation). Key research areas include soil and groundwater contamination and remediation, surface-groundwater interactions and green roof technology. RESTORE combines state-of-the-art laboratories, field research, advanced computer modeling, and commercialization with national and international collaborations, and strong industrial partnerships to achieve research excellence. To learn more, visit

<https://www.eng.uwo.ca/research/restore/index.html>

Learning Goal:

- Students will learn about renewable and non-renewable energy sources
- Students will learn about green chemistry
- Students will learn about wind turbines
- Curriculum Connections: Grade 7 - Structures and Mechanisms: Form and Function and Understanding Earth and Space Systems: Heat in the Environment. Grade 8 - Structures and Mechanisms: Systems in Action.

Materials Needed:

- Straws
- Construction Paper
- Cardboard
- Tape
- Popsicle Sticks
- Skewers
- Hot Glue & Glue Gun



- String
- Small weight (e.g. washers)

You will also need a hair dryer or small fan for the testing procedure.

Engineering and Science Connections:

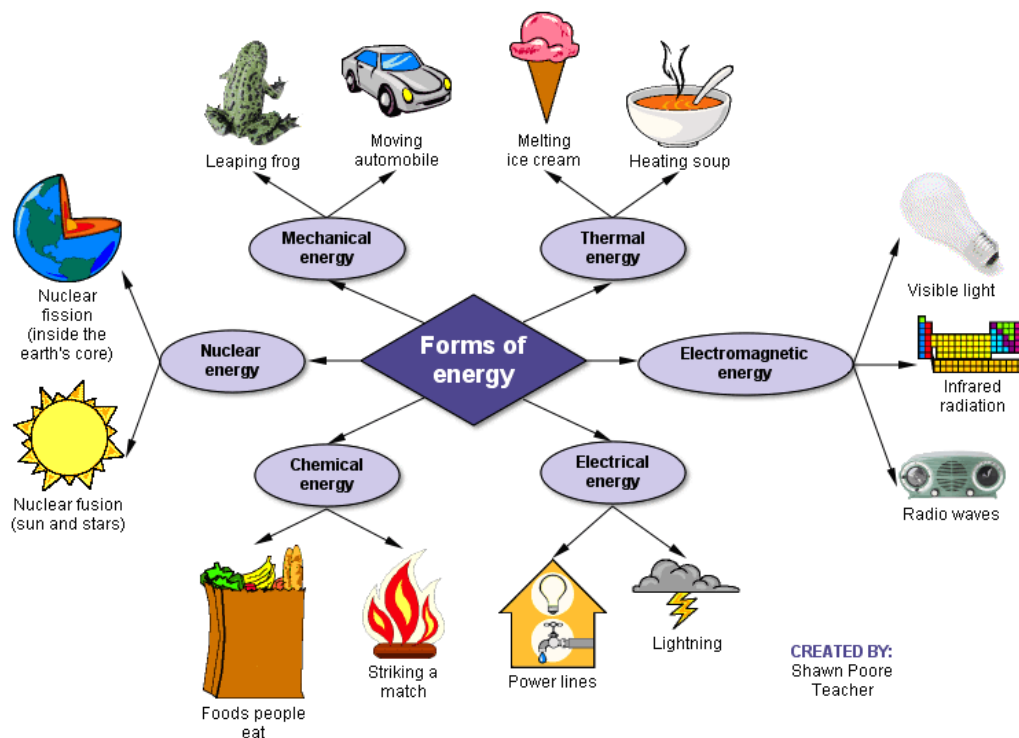
Today we will be talking about renewable energy and green chemistry as well as how wind turbines work!
What are some examples of renewable energy sources?

What is Energy?

Energy is the ability to do work! Humans use a variety of energy sources in our everyday lives.

6 Forms of Energy

- 1) Chemical
- 2) Electrical
- 3) Electromagnetic
- 4) Mechanical
- 5) Nuclear
- 6) Thermal



There are numerous environmental and economic impacts to using these energies. We can find ways to reduce these impacts through recycling and “being green”, which is to conserve energy by being careful consumers.

12 Principles of Green Chemistry

1. **Prevention:** It is better to prevent waste than to treat waste or clean it up after it has been created
2. **Atom Economy:** Synthetic (man-made) materials should be designed to maximize the incorporation of all materials used in the process to the final product (no waste created)
3. **Less Hazardous Chemical Synthesis:** When possible, synthetic methods should be designed to use and make substances that are not very or not at all toxic to human health and the environment.
4. **Designing Safer Chemicals:** Products should be designed to affect their desired function while minimizing their toxicity
5. **Safer Solvents and Auxiliaries:** The use of solvents (AKA auxiliary substances, a very big word) should be made unnecessary whenever possible and when solvents have to be used they should be non-toxic (ex. Alcohol is an example of a less toxic solvent, water would be a non-toxic solvent)
6. **Design for Energy Efficiency:** Energy requirements of processes should be recognised for their environmental and economic (cost) impacts and should be minimized.
7. **Use of Renewable Feedstocks:** A raw material or feedstock should be renewable rather than depleting whenever possible.
8. **Reduce Derivatives:** unnecessary derivatization (use of blocking groups, or temporary modification of physical/chemical processes) should be minimized or avoided if possible, because adding these extra steps require more reagents and can generate more waste.
9. **Catalysis:** Catalytic reagents are superior to stoichiometric reagents. This means that you have to use a catalyst in your reaction. A catalyst makes a reaction happen faster. Why do you think this is helpful? So that you can add less of the reactants and use fewer materials!
10. **Design for Degradation:** Chemical products should be designed so that they breakdown in a way that does not harm the environment and do not stay in the environment for very long - aim for things that are biodegradable.
11. **Real-time Analysis for Pollution Prevention:** This means we should develop some more methods to analyze pollution production so that we can pollute the environment less!
12. **Inherently Safer Chemistry for Accident Prevention:** The substances that we use in a process should be chosen to minimize the potential for chemical accidents. Accidents could be releases, explosions or fires, among other things.



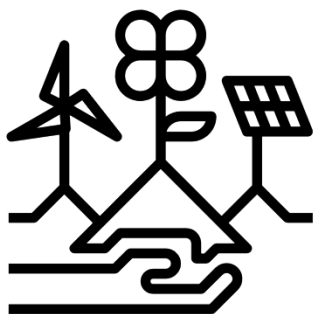
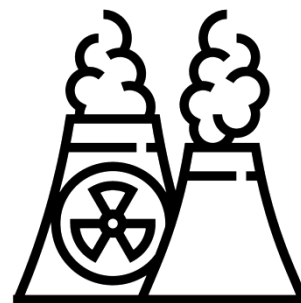
How does renewable energy relate to the 12 Principles?

It relates to atom economy, less hazardous chemical synthesis and design for energy efficiency.

When you compare this to non-renewable energy sources, what are some of the pros and cons to both forms of energy?

Renewable Energy: Hydropower, Solar, Biomass, Wind, Geothermal

Non-Renewable Energy: Fossil fuels, Coal, Nuclear, Natural Gas



In general, non-renewable energy sources have much larger negative impacts on the environment but are easier and cheaper to use in large-scale ways at the moment. Much research is being done to find greener alternatives to fossil fuels, coal, and natural gas and lower the cost of these alternatives so that they can be financially feasible solutions. Although nuclear energy is non-renewable, it is considered a generally 'green' energy source in comparison to the rest. However, nuclear energy comes with its own significant challenges that many green process and chemical engineers consistently work towards mitigating.

Renewable energy sources are much 'greener' but require more innovation and often take up more space (e.g. large solar or wind farms) than non-renewable sources in order to supply energy on a large scale. Again, much research is being done by scientists and engineers in this field.

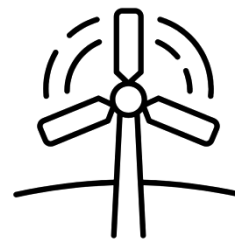
How do Wind Turbines Work?

Wind turbines work the opposite to a fan - instead of using electricity to make wind, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

A good turbine should have large blade surface area and curves to catch the wind from more than one direction but there are infinite possibilities of designs within these guidelines. There are many forms this structure can take in order to perform its function.

There are some factors to consider when building a wind turbine, such as:

- Where to locate them?
- What is the best shape?
- How many blades are most efficient?
- What materials would you use?
- Cost vs. efficiency



Video Recommendation: *How Does a Wind Turbine Work?*

<https://www.youtube.com/watch?v=D1JJwsF13w>

Activity:

Before you start, think about the following questions:

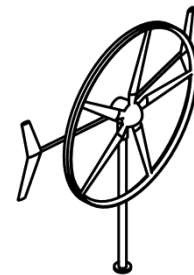
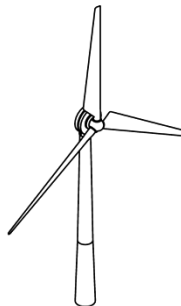
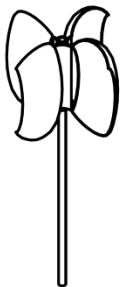
- Which of the 12 principles are we taking into account in this activity?
- Which forms of energy are we dealing with?

New Wind Farm!

To try to make Ontario's energy a little greener, a new wind farm is being built near London, ON. The engineers are working hard to get this project going, but are running low on inspiration. They have asked for new design ideas for the turbines!

Your task is to design a wind turbine for the engineers. The turbine prototype should have a small weight attached to the axle by a string. It should be able to pull the weight up from the "wind" (hair dryer or fan). Tip: sketch your design before starting so you have something to look back on.

Once your prototype is complete, test its energy efficiency with the fan or hairdryer by testing if the weight successfully rises due to the "wind". If not, re-think your design to have a larger turbine surface area or a more optimal angle for the direction of the wind. Good luck and have fun!



What Did You Learn?



- What are examples of renewable energy sources?
- What are the 6 forms of energy?
- What are the principles of green chemistry and why are they important?
- What are some of the pros and cons of renewable vs non-renewable energy?
- What are some criteria to keep in mind when designing wind turbines?

Future Learning



- Try your design with a different wind angle. What changes? How would you alter your design to work even when the wind is coming at a different angle?
- Draw up a completely new and different design and test it against the other one. Which one seems to work best? Why do you think that is?

Share your creations!

We would love to see what you made. Email us at discover@uwo.ca or tag us on social media.

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Thanks for discovering with us!