What Can You Do for Solar?
Chemistry in Energy
(An "Expansion Pack for Chemistry)
Created by Rebecca Hooper
In the QESST Engineering Research Center Research Experience for Teachers Program

Purpose: Provide a real world, relevant experience for students to connect to chemistry material taught for a deeper understanding and higher retention of concepts.

Objectives

- Students will be able to answer the question, "What can you do for solar?", finding their role in the world's solar energy future.
- Students will be able to apply concepts of atomic structure to explain how energy is obtained to produce electricity.
- Students will be able to identify different types of energy and their source including their process, societal Impact, environmental impact, etc.
- Students will be able to explain how solar energy is harnessed and what factor affect its usefulness.

Problem. AP Chemistry is often taught with a ticking time bomb going in the background. The race against the clock to cover as much material as effectively as possible by the first Monday in May is a tough race. Teachers often find themselves having to speed through material in order to cover as much as possible prior to the exam.
This speedy pace often results in teachers failing to connect course content to the real world. Students don't have an impactful, personal experience with the concepts. Very little relevance is given to drive students to think of potential careers, implications in the science community or society. As a result both teachers and students are missing opportunities to greatly improve in their level of comprehension and retaining concepts. Students also continue to miss out on understanding the nature of science and being a part of the science community.

Solution. Expansion lessons are implemented into a unit where the existing material is applied and made relevant via research and inquiry. These additional tools will contain a connection to current scientific research and large societal issues, yet culminate to a specific activity, task, etc.

> **Specifics**. After a unit on atomic structure students experience how the electrons of an atom are used to produced various types of energy.

Hypothesis/Predicted Results:

- Students have higher motivation to learn material and be engaged in material
- More significant, deeper level of understanding of concepts
- Higher retention over time due to application of concepts
- More valid understanding and proper implementation of the scientific process
- Students are aware of various forms of energy and their significance
- Students take ownership in their role in scientific community
- Students recognize and embrace an issue greater than themselves

Prior Knowledge/Unit:

AP Chemistry	Chemistry 1
Big Idea 1	2. Demonstrate an understanding of the atomic model of matter by exclaiming atomic structure and chemical bonding. b. Discovery of current model of atomic structure c. Model based on the fundamental particles
1.A – Atoms & Elements 1.B – Atomic Structure and Interaction of Electrons 1.C – Quantum Mechanical Model 1.D – Electromagnetic Waves	3. Develop an Understanding of the Periodic Table.

Essential Question:
How are energy sources and electrical energy dependent on the structure of an atom?

Timeline: The entirety of this lesson can take 12- 14 days. However different activities can stand alone as 1-2 days lessons, homework assignments, lab experience, etc.

Overview (2-3 weeks):
Types of Energy Learning Cycle
1. Exploration
   a. Students "play" with various energy modules (solar car, wind turbine, etc.)
   b. Students hypothesize how each module works, what they are used for, etc.
2. Concept Intervention
   a. Class discussion defining energy, electricity, and electrical energy.
   b. Students research an assigned type of energy.
3. Concept Application
   a. Student design, implement, and analyze an experiment to optimize the amount of energy from one of the modules they explored.

Solar Energy Learning Circle
1. Exploration
   a. Students build a dye-sensitized solar cell to see the requirements to get the energy from the sun converted to usable energy.
2. Concept Intervention
   a. Students read, draw, and discuss Ella the Electron, a story of how the electrons travels to produce energy in a solar cell.
   b. Students Connect to story to an actual solar cell given an overview of the cell's structure and vocabulary terms.
3. Concept Application
   a. Students design, implement, and, analyze an experiment to test a parameter in order to produce to "best" dye sensitized solar cell.

Learning Cycle 1: Sources/Types of Energy

Exploration

	Student Action	Teacher Action	Purpose/Goal
	Phet Simulations of Energy	**1 Day (Optional HW)**	
Interactive	In groups of 2-3 students explore Phet Simulations of energy online. Assigned an energy pathway students work together to connect the simulation to the energy stations and overarching themes and/or laws of energy and how it works. Create a poster to share with the class Mechanical – girl on bike Hydropower- water wheel Steam – kettle Solar – sun and solar panel.	Suggested to download simulations to computers prior to lesson. Pose discussion questions to get students going in a conversation. Lead class in identifying commonalities among all groups.	Hook using different interactive media. Establish that there are different types of energy. Laying foundation prior to bringing in the role of the atom
	Energy in Action Stations	**1 Day**	
Constructive	Students explore energy stations completing the "Energy in Action" handout Students will explore a system and predict the source of energy, type of energy, and how it works. Draw the system add label of movement of energy using same memos from Phet. - Wind turbine - Solar car - Hydropower	Set up stations according to teacher instructions. Keep students on task and time. Discuss their answers and observations getting them to draw out more from the experience than just the surface level of the activity.	Hook, motivating, fun Establish and identify preconceptions. Continue to lay foundation
Note: The order of these two activities can be switched. Either can be done individually or in groups.			

Concept Intervention

	Student Action	Teacher Action	Purpose/Goal
	Defining Energy Terms	**1 Day**	
Constructive	Students define their initial understanding of the terms electricity, energy, and electrical energy. They will incorporate what they have learned from the atomic structure unit.	Do not give students any information. If they struggle to start ask questions to help them recognize their current understanding. i.e. What do you think of when you hear the word? What are adjectives or verbs that are usually used with the word?	Establish and identify prior knowledge. Well Connect to atomic structure after identifying.

Interactive	Students discuss their definitions and explain their understanding based on content knowledge or life experience. (Optional: whiteboard) As a class come up with a concise definition for each word. In deciding, students explain reasoning for what they include and what they exclude.	Facilitate discussion. Allow students to lead, only interject to keep them on topic and make them elaborate or justify weak claims. Identify commonalities and differences between definitions.	Flush out misconceptions. Identify and differentiate individual levels of understanding versus the whole.
Active	Look up definitions of each term. Compare, contrast definitions.	Help extract the difference in the definitions. Suggestion: pose the question, "Is one definition necessarily right or wrong?" Establish with students the gray areas of science where there may not be either/or, right/wrong.	Solidify understanding of terms. Increase confidence level and lower grade anxiety
	Students answer questions on the reverse of northwards bridging atomic structure to definitions.	Remind students what they know of ads that will assist in answering questions.	Introduce atomic structure by identify the electron as the key particle in energy.
	Energy Analysis	**2-3 Days**	
Active/Constructive	Students are assigned a type of energy and complete the "Energy Analysis" handout. Students will research a type of energy source, the process of becoming usable, and discuss the type, renewability, Impact on the environment, pros and cons, place in policy/Government, viewed by public, limitations, production of future, personal opinion/Impact.	Clarify assignment as requested.	Student ownership of role and interpretation of energy. Incorporate atomic structure to a specific form of energy.
Note: Assign this a few days prior so that this next portion can begin the day after "Defining Energy Terms" Option: Require students to create a poster summarizing their energy source or create a PowerPoint on Google docs to have students add 2-3 summary slides.			
Constructive/interactive	Students share what they discovered about the types of energy. Students summarize the process of each type and relate it to their own. Students choose an energy other than their own and complete a quick write with the following prompt: Create a fairytale story about an electron that tells how it goes from that energy source to power an object. Students will peer review each other's stories and justify suggestions.	Give ideas on how to get the story going and keep it accurate. Facilitate peer review.	Students are exposed to all types of energy. Expose them to the use of an analogy to describe how electricity is created.
Optional: Fairytale can be a homework assignment. Students can post stories one night then critique each other's work the next online.			

Application

	Optimal Energy Experiment	**2-3 Days**	
Interactive	In groups of 2-3 students design and conduct an experiment for one of the exploring energy activities that will optimize its energy output. Must complete "Energy Experiment" handout and have procedure approved before beginning. Students will collect, analyze, interpret, and present data.	Put no limitations on investigating ideas, but reinforce proper methods of the scientific/engineering process, testing only one variable at a time, recording data Provide materials. Do not assist directly with design, ask questions to get students to realize their own mistakes, limitations so they improve.	Critical thinking, Lab Design Process, Creativity
Optional: Turn it into a competition of which group generated the most energy. Can lead to debate about "fairness" because of the limitations of certain energy methods.			

Learning Cycle 2: Solar Energy

Exploration

	Dye-sensitized Solar Cell	**1 Day**	
Active	Students follow procedure of Berry Lab via a video lesson, recording observations and data.	Set up Materials. Play and stop video for students to follow. Ask questions to have students predict the purpose and importance of each step.	Witness first-hand how solar energy works. Get an idea of components required.
Note: Can have students complete the first step the day prior art the end of class so it can dry or the teacher can prep that step so it is ready to go.			
	Ella the Electron	**1-2 Days HW**	
Constructive	Students read the story Ella the Electron and after each scene draw and label a depiction of what they picture is occurring.	Put no limitations on drawings other than adhering to story and labeling bolded words.	Students are introduced to how a solar module works in a fun way that allows them to be creative.
Note: Assign 1-2 days prior so students have it completed the day after the "Dye-sensitized Solar Cell" Option: Complete in class, have students work in small groups. Assign each group a scene from the story to read, analyze, and draw an illustration. Starting with scene one walk through with the students Ella's journey.			

Concept Intervention

Interactive	In pairs, students are given a handout that shows the layers of a solar modules and a list of solar energy vocabulary. Together, using their illustrations, they connect the story to the actual parts of a wafer. Identifying the pathway of the electron and purpose of each layer and important processes that occur.	Go through brief overview of how electrons travel through the layers as a foundation prior to explaining the assignment. From then just clarify specific questions students may have.	Take the analogy to real world terms and understanding.
Interactive	Given a missing or replaced part of a layer of the solar cell students predict how it could possibly affect the function, performance, and efficiency of the module. In groups, students whiteboard responses and, as a class, discuss their answers.	Lead students through understanding by presenting missing/replaced parts. Identify the function/purpose of the original party's and properties that allowed it to perform properly then compare to new or missing situation. Focus on not only on how the cell would be affected but also why referring to atomic structure content.	Identify misconceptions. Deeper understanding of the purpose of the parts of a solar panel and how it works.
Constructive/interactive	Individually students find parts of the berry solar that are analogous to a silicon wafer module. Justify each claim made either based on function, location, appearance, etc. In groups students compare them together determine general requirements or laws for any solar cell.	Make sure analogies are plausible, inquire students about the why behind their choices.	Demonstrate understanding of how solar energy works.

Application

Interactive	Students optimize the internal factors of the dye-sensitized solar cell. They choose a parameter and design an experiment to test the effect it has on the cell. As a class try to create the most optimized cell.	Differentiate between a demonstration and an experiment Critique, flush out issues with the procedures Challenge students to go beyond the obvious	Students demonstrate their understanding off the role of the parts of a solar cell

Interactive	As a class determine the external factors that affect solar energy the most. Students design a lab with a solar car and test one parameter (i.e. Angle of panel, number of panels, clear coverings, amount in sunlight, etc.) Determine the optimum conditions for your factor of a solar car. They will make a detailed procedure, record data, create proper data and graphs. Discuss results with peers.	Differentiate between a demonstration and an experiment Critique, flush out issues with the procedures Challenge students to go beyond the obvious	Students utilize what they learned from a previous design to improve upon another.

What to know:

- The layers of the silicon wafer are on the microscale level in terms of width so students can't see and may have a hard time accepting such a thin object has layers.
- Silicon wafer and solar cell are often used interchangeably and in PV that seems to be accepted. However not all silicon wafers are used for solar and not all solar cells are made of silicon.

Acknowledgement: *This material is based upon work primarily supported by the National Science Foundation under award No. 1560031 and by the Engineering Research Center Program of the National Science Foundation and the Office of Energy Efficiency and Renewable Energy of the Department of Energy under NSF Cooperative Agreement No. EEC-1041895.*

Energy in Action
Phet Simulations and Activity Stations

Phet Simulations:

- Google: "phet simulations energy forms and changes" – choose first link: https://www.compadre.org/precollege/items/detail.cfm?ID=12729
- Click the play button (Java is required)

Object Identification:

Energy Input:

Energy Converter:

Energy User:

Compare/Contrast:

	Object 1	Compare	Object 2
Energy Inputs			
Energy Converters			
Energy User			

Observations of Energy Systems:

System	Observations

Reset All → Select “Energy Symbols” → Turn on water flow → Sketch with energy symbols

Water:

Sketch	Description

Sun:

Sketch	Description

Types of Energy Defined:

Mechanical	
Electrical	
Thermal	
Light	
Chemical	

Connections:
1. Which energy input is a PRIMARY SOURCE (originator) of energy? Explain.

2. How is atomic structure critical to this type of energy? Explain.
(keywords: photons, electromagnetic radiation, quanta, wavelength/frequency, electrons, etc.)

3. Does any other type of energy rely on atomic structure as much? Why or why not?

Energy in Action Stations

For three of the activity stations complete the following:
Sketch with energy symbols - Describe the energy flow

Station	Sketch	Description

Reflection:
1. Compare and contrast two activity stations:

2. Explain how atomic structure is integral (or not) for any two of the activity stations.

3. Which two (one from phet, and one activity) are most closely related? Explain.

4. Identify commonalities, laws, must haves of energy systems overall.

Extension:
5. One type of energy not in the activities or phets is Nuclear Energy, which is where most of our energy comes from. Draw a sketch with energy symbols of a nuclear power plant with the energy source being an item at your house. Describe the energy flow.