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Activities for Engaging High School Students in Energy Studies



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Energy

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This guide is purposed to direct teachers of grades 9-12 to the activities, lesson plans, curriculum, videos, and resources necessary to educate students in renewable energy and applications of energy inside and outside of the classroom. Use the guide to foster student engagement in the global conversation of fossil fuels, alternative energy sources, and energy-efficient lifestyle choices, school investments in energy efficiency and production, and home-energy use. In each section of the table of contents you will find major concepts, leading questions, and resources denoted in *italics* such as “*videos*”, “*lesson plans*”, and “*curriculum*”. Distribution of these materials is appropriate and highly encouraged inside the classroom.

To start out, let Bill Nye introduce basic energy concepts to the classroom

[Bill Nye: The Science Guy – Energy \(Full Episode\)](#)

In the Home

Current Energy Use

- When at home, ask your parents to look at the last utility bill for electricity and natural gas. What company or companies deliver(s) energy to your home?
- Electricity
 - What is a kilowatt? How about a kilowatt hour? What’s the difference?
 - Ask your students to bring in a copy of their most recent home electricity bill to class.
 - How much is your family paying for electricity delivered to your home?
 - Total? Per kilowatt?
 - Video [What’s a Watt?](#)
 - In this video students will learn the basic unit of power in terms of human energy production during physical activities, and the relationship between energy source (food) and production (Activity).
 - Video [What is a Kilowatt Hour?](#)
 - Explanation of the kilowatt-hour using home electronics. Produced by the government of Ontario.
 - How much electricity, in kilowatts, did your home consume last month? Last year?
 - An average home in America consumes roughly 1000 kilowatt hours a month. How does your home compare to this average? Does your monthly electricity use

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change? Is there a trend? What external factors might contribute to the fluctuations in energy use?

- *Article* [Homes Show Greatest Seasonal Variation in Electricity Use](#)
- What electric utility delivers electricity to your house?
 - Search online for the utility website and find its energy sources portfolio. The portfolio is made of electricity-generating plants that may use a lot of different sources of energy for power. What are these sources, and what percentage of the electricity is produced by each?
 - Ie: <https://pse.com/aboutpse/EnergySupply/Pages/Electric-Supply.aspx>
- What is the electricity portfolio of your state? Search the Energy Information Agency (EIA) online to find yours!
 - Ie. <http://www.eia.gov/state/?sid=WA>
 - Why do states' energy portfolios differ?
 - How does your state compare to Washington State in its energy portfolio?
- Natural Gas
 - What is a [BTU](#)? A [therm](#)?
 - Ask your students to bring in a copy of their most recent home natural gas bill to class.
 - How much is your family paying for natural gas delivered to your home?
 - Total? Per kilowatt?
 - What in your home uses natural gas as an energy source?
 - What alternative forms of energy could be used for the same purpose?
 - How could you reduce your natural gas bill?
 - *More Information* [What Can You Do to Help Reduce Your Natural Gas Bills?](#)
 - Is there infrastructure for natural gas around America? Why does every urban American home have access to natural gas instead of a home-tap for petroleum-based fuels? If natural gas is so clean, why don't we just burn it in our homes to produce electricity for the household?
 - *More Information* [How Does the Natural Gas Delivery System Work?](#)

Home Energy Audit

- *Lesson Plan (multi-day):* [How to: Home Energy Audit](#)
 - *Included you will find activities and homework that covers: Household Conservation/Efficiency, Watt Meters to Measure Energy Consumption, Home Energy Audit, Light vs. Heat Bulbs, Life Cycle Cost Analysis*
- Energy Efficiency
 - In your kitchen, look for a sticker on your appliances that says "Energy Star". What appliances do you see with this sticker? Do you see these stickers anywhere else in your home? Where?
 - What is [Energy Star](#)?

Home Energy Use – Next Steps

- Energy Reduction
 - Discuss ways to reduce the energy use in your home

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- Think about what consumes electricity or natural gas in your home. What uses a lot? What doesn't? Come up with a list of 10 recommendations for your parents to minimize your home energy use.
 - *More information* [100 Ways to Save Energy at Home](#)
- What could you do personally to use less electricity in your home without compromising your daily life?
- Onsite Renewable Energy
 - What technologies are available for consumers to power their homes onsite? How about off-grid? What does it mean for your home to be "off of the grid"?
 - *Article and Video* [How Living Off the Grid Works](#)
 - *Activity* Have your students write a one-to-two page paper on what they think life would be like off-grid. Tell them to focus on what would be different than their lives now? How would their routines change? Could they live off-grid the same as they do currently?
 - Ground-Sourced (Geothermal) Heat Pumps
 - *Video* [Energy 101: Geothermal Heat Pumps](#) *Article* [Geothermal Heat Pumps](#)
 - Questions. How do heat pumps work? What are the environmental benefits of using a geothermal heat pump vs traditional Air Conditioning? What is the difference between a vertical system and a horizontal one?
 - Residential Solar PV
 - *Activity* Have students research solar photovoltaics for the home and have them bring in one article about solar photovoltaics in your state. Place students into small groups to share the information they learned from the article before coming back to the full group.
 - Residential Solar Thermal (Water Heaters)
 - *Video* [How Solar Hot Water Works](#)
 - Why is a back-up unit needed to heat water in minter months? What side of the roof should you install a system to maximize efficiency (ie North, South, East, or West facing)?
 - How is your water at home heated currently?
 - Choose one fuel source that might make sense for powering your home. How does the technology to convert the energy source into electricity (or another useable form of energy) work? Why is it not already installed? Consider the environmental, economic, aesthetic, and other pertinent factors.

At School

- Current Energy Use in the Classroom
 - What is using electricity in the room right now?
 - With your class, perform a quick energy audit of everything that is visible. How many kilowatt hours are consumed during one class period. During a full day? A week? A year?
 - *Video* [Power Save Schools](#)
 - What could you and your class do to minimize that energy use without compromising the pedagogy and engagement in class?
- What's the biggest energy hog – in the classroom? In the building?
 - Why does it consume so much energy? Think critically about the piece of equipment, how it functions, and its necessity.
 - *Lesson Plan and Activity* [Lighting in the Library: A Student Energy Audit](#)
 - Subject: Energy Basics, Efficiency
 - Activity geared for introductory science classes
- How do we measure the brightness of lights?
 - *Video* [Energy 101: Lumens](#)
- Onsite Renewable Energy Sources and Demonstration Projects
 - *Video* [2013 Greenest School on Earth](#)
 - Questions: What renewable energy technologies did you see in the video? How did this school incorporate sustainability into its building?
 - Call to Action: Culminating Project to assist school in acquisition of on-site renewable energy
 - *Video* [Mercer Island Student Brightens up School with Senior Project](#)
 - Questions: What would it take to do a similar project at our school? What are your initial reactions from this video? How many hours a year could the solar panel array power a microwave for? How does the sunlight here compare to that of Washington State?
 - Solar PV, Thermal, geothermal heat pump
 - *Guide* [Renewable Energy at Schools](#)
 - This guide takes into account the experience learned in multiple school districts in the state of Minnesota concerning onsite renewables at schools. In this guide students, and teacher mentors, can learn the step-by-step process to install a demonstration and larger renewable energy systems at your school. In addition, the guide offers information on integrating the system with curriculum, project funding, and installation management.
- Recognition and Awards for Green Schools
 - [USDOE: Green Ribbon Schools](#)
- Additional Resources
 - *Curriculum Resource* Greening Schools [Green Your Lesson Plan](#)
 - *Lesson Plan* [How Green is My School? Conducting an Energy Audit](#)
 - Published in the New York Times
 - *Lesson Plan and Many Activities* [Science Projects in Renewable Energy and Energy Efficiency](#)

- Subjects: Advanced Vehicle Technologies & Fuels, Basic Energy Science, Biomass, Building Technologies, Electric Infrastructure Systems, Energy Analysis, Geothermal Energy, Hydrogen/Fuel Cells, Solar, and Wind Energy

In Transportation

Fuel and Energy Sources

- Traditional
 - Cars, trucks, and busses powered by gasoline
 - Why are most cars and trucks today powered by petroleum products?
 - Consider potential economic, social, legal, and environmental factors
- Alternative Fuel Sources
 - Hybrid Electric
 - Ie. Toyota Prius, Chevrolet Volt
 - *Video* [Energy 101: Electric Vehicles](#)
 - Do any of your families own an “EV”? What’s it like? What are some of the differences between EVs and traditional cars? Why doesn’t everyone drive an electric car? Is it possible that electric cars are “worse” for the environment than traditional ones? How could that be?
 - Natural Gas
 - *Article and Video* [How Natural-gas Vehicles Work](#)
 - Electric (plug-in)
 - Tesla Roadster/Model S, Nissan Leaf
 - Have your students research electric plug-in vehicles. Discuss the advantages of vehicles that only run on electricity. Discuss infrastructure, fueling durations, potential pitfalls (battery malfunctions in the Fisker Karma), and brainstorm the future of electric vehicles in your community.
 - Biofuels – What are they? How do we use them? Where do they come from? Can we make our own?
 - *Video* [Energy 101: Biofuels](#)
 - Questions: What is biomass? What are some common sources of biomass for biofuels? What is one way to convert biomass into biofuel? Is wood a biofuel? How do we use wood to produce energy?
 - *Video* [Energy 101: Algae-to-Fuels](#)
 - What is algae? What are the advantages of algae biofuels? What is carbon-neutrality? What makes algae biofuels carbon neutral when burned? Why would you want to put an algae farm next to a coal power plant?
 - *Lesson Plan* [A Pre-Treatment Model for Ethanol Production Using a Colorimetric Analysis of Starch Solutions](#)
 - Subject: Bioenergy

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- Activity geared for a higher level chemistry class
- *Lesson Plan* [Reaction Rates and Catalysts in Ethanol Production](#)
 - Subject: Bioenergy/biomass
 - Activity for a general/environmental science or chemistry/biology class
- *Lesson Plan and Multiple Activities:* [The Biofuel Project: Creating Bio-diesel](#)
 - Subject: Bioenergy
 - Activity geared for higher level chemistry class
- *Lesson Plan and Multiple Activities:* [Renewable Energy Plants in Your Gas Tank: From Photosynthesis to Ethanol](#)
 - Subject: Biomass/Bioenergy
 - Three activities on Plant Pigment Chromatography, Plant Mass, and Stored Chemical Energy
- More Resources
 - *Curriculum* [Cars of Tomorrow and the American Community High School Curriculum](#)

Biking, walking, and using your two feet

- Food energy – what should you eat to provide the most power!
- Why does what you eat either help or hurt your ability to move faster
- How do we measure the energy in food? What unit do we use?
- What foods give you the biggest boost in energy? Which are “better” for you? Which do you want most? What tastes the best? Does your personal taste in food correlate at all to the energy stored in the food? Discuss why that could be and think critically about the reasons behind why we perceive these foods to taste so good.

Mass Transit

- Busses, trains, trolleys, light rails, and metro
- What mass transit options do you have in your community? What kind of fuel source do they use? E.g. most buses in America run on petroleum based fuels and many urban busses can run on electricity. Underground subways along with most urban trains run on electricity.
- Benefits of Mass Transportation
 - *Research* Have your students research one form of mass transportation and the advantages and disadvantages of the fuel source. Why is the fuel used? Is there a “better” alternative? If so, explain.
 - Reduction in energy/person consumed in transportation
 - Environmental Externalities
- Comparing alternatives for school bus fuel. Mind the Jeopardy-esque background music. Have your students watch these videos back to back:
 - *Video 1* [Michigan Transports Students in Hybrid Electric School Buses](#)
 - *Video 2* [Propane Buses Help Minnesota Schools Carve out Greener Future](#)
 - *Video 3* [Natural Gas School Buses Help Kansas City Save Money](#)
 - Questions: In each video a school district invests in new technologies for their buses to save costs and have cleaner emissions. Why is propane considered a cleaner alternative to diesel and gasoline? What are the advantages and disadvantages of using the fuel? What is a hybrid-electric school bus and how does it work? What are the advantages and

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disadvantages of the hybrid technology and conventional engines? What is compressed natural gas? What makes it green? Compare and contrast the three different fuels shown in the videos. Does your school district operate any buses that use alternative fuels or electricity? If so, what are they like? Do you notice anything different about them when riding? Discuss. Is there a “best” option? Why/Why not?

Student Competitions

- Shell Eco-Marathon: <http://www.shell.com/global/environment-society/ecomarathon/events/americas.html>

In the Community

The Grid

- What is it?
- Some call the grid a giant battery. Why? How does the grid compare to a battery?
- Production
 - Is there any coal power in your state’s energy mix? Where is the closest coal plant located? Why is coal so bad? Why are we, as a country, moving towards cleaner fuels?
- Delivery
 - How does electricity move from a point source like a coal power plant to your home? Are there losses of energy in the transmission? If so, why? Where does the energy go if not directly to your home? Consider heat loss over distance.
- *Full Curriculum: [The Energy Sourcebook High School](#)*
 - *Helps students understand the history and application of every major energy source and provides simple DIY activities to show how each technology works. Information is specific to the Tennessee Valley but can be applied universally. This sourcebook is purposed to help teachers prepare students through real-life application sand principles of energy studies.*

Grid 2.0

- Smart grid management
 - *Video [Smart Grid](#)*
 - How fast does electricity travel? Why do we need back-up power plants? In what decade did utilities start putting sensors all over their transmission lines? What is a smart meter? Imagine a time in the future when a utility could turn your home appliances on and off for you. How does that make you feel?

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- Check out the [Department of Energy's site on smart grid management](#) for more information.
- Microgenerators and Distributed Generation
 - Solid-Oxide Technology
 - *Video* [60 Minutes: The Bloom Box](#)
 - What is a fuel cell? How does the bloom box convert fuel to electricity without combustion? What are some applications of the bloom box?
- Connecting renewable sources
 - *Activity* Ask your students to find an article about electric utilities fighting against residential onsite electricity generation (ie from solar or wind). Discuss the debate between the traditional model of large-scale production of electricity and the emerging model of distributed generation.

Renewable Energy

- Utility scale renewable energy production
 - Wind Energy
 - What are the benefits of power produced from wind?
 - How do wind turbines generate electricity
 - What are the pitfalls of this energy source?
 - What percentage of your state's energy mix is produced from this source?
 - Why don't you see more wind turbines around?
 - Find the closest wind turbine farm to your school. What is its generating capacity?
 - *Video* [Energy 101: Wind Turbines](#)
 - Questions: Why are wind turbines so tall?
 - *Lesson Plan* [An Exploration of Wind Energy and Wind Turbines](#)
 - Subject: Wind Energy
 - Activity is geared for a general/environmental science class
 - *Lesson Plan* [Wind Energy Basics](#)
 - Subject: Wind Energy
 - Activity geared for science/math classes
 - *Teacher Guide* [Exploring Wind Energy](#) and *Student Guide* [Exploring Wind Energy](#)
 - Subjects: Energy Basics, Energy Efficiency and Conversion, Wind Energy
 - Hands-on activities that provide a comprehensive understanding of the scientific, economic, environmental, technological, and societal aspects of wind energy to students in grades 9-12. Geared for curriculum in the sciences, social studies, language arts, and general technology.
 - Additional Resources
 - <http://www.awea.org>
 - Solar Photovoltaic (PV) Farms
 - What are photons? Where do they come from?
 - What are solar photovoltaic panels?
 - *Video* [Energy 101: Solar PV](#)

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- Questions: What are the negatives and benefits of Solar PV? Where in the world has the most PV panels? What country leads the world in solar power production?
- *Teacher Guide* [Exploring Photovoltaics](#) and *Student Guide* [Exploring Photovoltaics](#)
 - Hands-on investigations to teach secondary students how electricity is generated using photovoltaics and other systems. Students will explore the variables affecting photovoltaic cells.
 - Curriculum geared for science, social studies, mathematics, language arts and technology
- Additional Resources:
 - <http://www.pvresources.com/>
 - <http://www.pvselect.com/index.php>
 - http://www.fsec.ucf.edu/en/consumer/solar_electricity/basics/index.htm
 - <http://www.solardecathlon.gov/>
 - <http://ocw.mit.edu/ans7870/SP/SP.769/f04/java/pvapplet/PVPanel.html>
 - <http://www.trec-uk.org.uk/index.htm>
- Concentrating Solar Power (CSP)
 - *Video* [Energy 101: Concentrating Solar Power](#)
 - *Lesson Plan and Activity* [Green Fuel: Exploring Methods to Collect Solar Energy](#)
 - Subject: Solar Energy
 - Activity: The BTU or Bust Project, geared for 11th-12th grade Science & Technology Education
- Solar Thermal Facilities
- Geothermal Energy
 - *Teacher Guide* [A Geothermal Teacher Guide for Grades 9-12](#)
 - Subject: Geothermal Energy
 - Geared for teachers of Ancient and Western Civilization, World and US History, US Government, Geology, Earth Science, Environmental Science, and Physical Science
- Hydroelectric Power
 - *Video* [Energy 101: Hydropower](#)
 - Questions: How do hydroelectric dams work? What is the difference between impoundment, pumped storage hydropower, and diversion? Where is the closest dam to your school? What are the negatives of building dams? How many dams are in the US and about how many are power-producing?
 - *Curriculum* The Nature of Water Power: [A Hands-On Science Curriculum for Students](#)
 - Published by the Foundation for Water & Energy Education
- Marine and Hydrokinetic Energy
 - *Video* [Energy 101: Marine and Hydrokinetic Energy](#)

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- Discuss the advantages of using water to generate power.

Renewable Energy Credits

- What is a Renewable Energy Credit (REC)?
- Who benefits from REC purchasing?
- Why do people, businesses, and even communities purchase RECs?
- Search online and find a business or organization that offsets their energy use from non-renewable sources with RECs. What other ways are there to reduce or offset fossil fuel consumption in buildings?

Student Competitions

- The 2014 National Science Bowl: <http://science.energy.gov/wdts/nsb/>
- Igniting Creative Energy Challenge: <http://www.ignitingcreativeenergy.org/>

Around the world

- What is the most commonly used source of energy for heat? For lighting? For electricity?
- Where in the world do you see transportation fueled primarily by renewables?
- What country produces over 90% of their electricity from renewable energy sources
- What is the global electricity production capacity? How about total electricity consumption?
- How much energy, in watts, is emitted through photons from the sun to the Earth over a given year? How does this compare to our current annual electricity consumption? Is it possible to power our global society only from the sun? What factors make solar power unreliable?

This resource guide was assembled by Harry Bolson, a student at Washington University in St. Louis graduating in May of 2014. Harry has majors in Finance and Entrepreneurship and a Certificate in Sustainable Management and Organizations. In the past six years he has focused his research and endeavors in renewable energy and the environment. His work experience includes the marketing, sale, installation, project management and leadership, education, and business development in residential and small commercial renewable energy systems and Renewable Energy Credits (RECs).

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For questions, comments, or follow-up on this guide you can reach out to Harry at hbbolson@wustl.edu. Harry is open to video conferencing in and talking to students about applying what they have learned in class in the “real world” and for mentorship on onsite or community renewable energy projects.