STRATEGIC ENERGY INNOVATIONS

Grade: 9-12

Version 2

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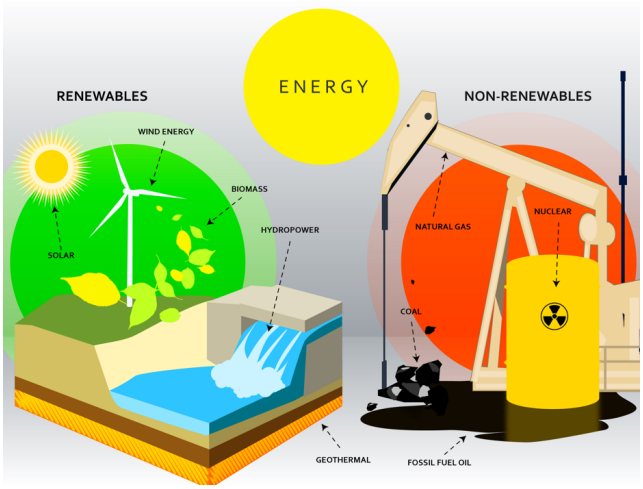
Introduction to Green Technology



A semester or year-long UC A-G, D-Lab Science course that introduces students to career opportunities in sustainable fields. Designed to meet the California Career Technical Education Standards for the Energy, Environment, and Utilities sector.

Intro to Green Tech Course Outline & Unit Descriptions

The purpose of the SEI Introduction to Green Technology course is to develop student awareness of and skills for career opportunities in sustainable STEM fields. Designed to meet the California Technical Education Standards for the Energy, Environment, and Utilities (EEU) sector – Energy and Power Technology Pathway, students conduct a series of scaffolded projects (described below) which are supplemented by suggested field trips and shadowing of professionals in the green field.

The goals of the Course are:

- To create energy and sustainability career awareness
- To develop technical and professional skills for energy and sustainability careers
- To create an informed citizenry that is engaged in creating sustainable energy systems

Course Themes:

The following overarching themes are integrated throughout the course. As an instructor, continuously revisit these big picture themes with your students, especially when transitioning from one unit to the next, to help students connect with the larger context and importance of the work they are doing in this course.

1. *High functioning energy systems are essential to economic, social, and environmental quality of life.*
    - Energy sources, the electrical grid, and energy policy are in an era of significant change. These changes have economic, social, and environmental impacts. Knowledge of these systems is essential to students' ability to ensure an equitable and sustainable future for themselves and their communities.
2. *Sustainability challenges are opportunities for students.*
    - Collectively we are facing pressing sustainability challenges that require creativity, innovation, and leadership to address. We need engineers, entrepreneurs, politicians, media experts, teachers, designers, builders, and leaders. No matter what students' interests, background, and skills are, they can make a good living while helping to address the most important economic, social, political, and environmental challenges of our time.

To summarize, this course is designed to help students to develop awareness and skills to be leaders and innovators through energy and sustainability careers.

<u>Journal Prompts on Course Themes</u>

These prompts can be used in each unit to revisit the overarching course themes above.

1. How do energy systems work?
2. How do energy systems affect economic, social, and environmental quality of life?
3. What would a "high functioning" energy system look like? Consider economic, social, and environmental implications.
4. How can I help to lead the transition to a sustainable future?
5. What challenges and opportunities do I see for myself and my community when it comes to Green Technology (or the aspect of Green Technology I just learned about)?

Unit 1: Sustainability, Energy, & Climate Change (~7.5 hours)

Students learn about sustainable design principles, strategies, and challenges in order to give them a broad picture of the opportunities for innovative solutions. Students complete hands-on climate science demonstrations, online activities, and research to explore the scientific causes and consequences of climate change, as well as the opportunities to address climate change and other pressing sustainability challenges.

Unit 1 Key Assignments

· Assignment 1: Exploring Home Energy Use

In this computer lab from the Exploring Sustainability Lesson of the SEI Solar Certificate, students explore their family's online energy account, making observations about the cost of energy, and their family's energy usage patterns over different times of day and year, to investigate the relationships between weather patterns, human activity, and energy usage. Students will complete a Handout to assess their family's daily energy usage and come up with recommendations for energy saving opportunities.

· Assignment 2: Strength of the Evidence

Students will complete a "Strength of the Evidence" Activity from the Investigating Climate Change Lesson of the SEI Solar Certificate. Groups of 3-4 students are each assigned a piece of "evidence". This evidence includes graphs and charts that demonstrate different impacts of climate change. The assignment can then be scaled to align with available instructional time. Options:

1. Each group discusses their piece of evidence and then briefly shares what their group learned and discussed with the class.
2. Groups can do research on their evidence and produce:
    a. A research paper
    b. A more in-depth class presentation and/or
    c. A poster presentation

· Assignment 3: Measuring Your Carbon Footprint

In this assignment, also from the Exploring Sustainability Lesson of the SEI Solar Certificate, students use the online EPA Carbon Footprint Calculator to calculate their family's carbon footprint, and measure how their family's average energy use compares to that of the average U.S. household. Once students complete their carbon footprint using the Carbon Footprint Calculator, they will participate in a class activity in which they graph their footprints and class totals in Excel. They will compare carbon footprints and discuss the cause of the differences, and come up with a list of actions students can take to reduce their footprints.

Unit 2: Fundamentals of Energy & Electricity (~12.25 hours)

Students are introduced to key energy system concepts, including energy policy, energy sources, power demand, and demand response. Students complete hands-on activities and labs that explore the fundamentals of the energy grid and power plant systems. Students will apply their critical thinking skills to synthesize information from recommended videos and activities, including online labs to explore the fundamentals of electricity, current, voltage, resistance, and electrical circuits as well as energy and power. They will demonstrate their knowledge of Ohm's and Watt's Laws.

Unit 2 Key Assignments

· Assignment 1: Unit Analysis Worksheets
Students complete unit conversions and dimensional analysis worksheets to build their math skills for later energy efficiency, energy conservation, and renewable energy calculations.

· Assignment 2: Build a Mini-Generator
Students learn about a key element in most electrical power plants – a generator. They build a mini-generator using a magnet and a coil of wire. They use an ammeter to measure the induced current in the coil of wire, analyze the impact a changing magnetic field has on inducing a current, and understand this fundamental component in most electric power plants.

· Assignment 3: Steam Turbine Lab
This activity allows students to model how fossil fuel, nuclear, concentrated solar power, and geothermal plants harness the heat energy to generate electricity. Students complete background reading on turbines and power plants. Then, student teams build a model steam turbine and alter their design to improve the performance of their turbine. Students analyze which design is most effective, and then evaluate the lab by answering questions and interpreting results in a data collection worksheet.

· Assignment 4: Local Fuel Mix
Students analyze the fuel sources used in the generation of their electricity through research. They will analyze how fuel mix impacts emissions factors and calculate the emissions associated with their home energy use.

Unit 3: Energy Efficiency & Conservation (~7.5 hrs)

Students investigate the rate structures of their utility providers and conduct an appliance and lighting energy audit to determine opportunities for reducing energy usage through conservation and efficiency. Students conduct a walk-through audit and then analyze their findings to develop and implement an Energy Conservation Action Plan.

(Note: Students will conduct a *full* technical school energy audit, including HVAC systems, in the subsequent Energy and Environmental Design course.)

Unit 3 Key Assignments

· Assignment 1: Lighting and Appliance Auditing
Students will conduct an appliance audit using a watt meter and conduct a lighting audit to determine optimal lighting levels and optimal lighting. Students learn about energy efficiency standards and estimate the total energy use, cost, and potential savings of appliances and lights. Students will learn how to distinguish between energy efficiency and conservation and be able to quantify savings of efficiency and conservation measures.

· Assignment 2: School Walk-through Audit
Students will use their newfound skills to conduct an audit of a representative sample of rooms in their school, recording energy usage in each room. They will also take pictures of energy saving opportunities that they observe throughout the audit.

· **Assignment 3: Energy Conservation Action Plan**
Students evaluate the data and observations from their walk-through audit to design a school Energy Conservation Action Plan, using the SEI Action Plan Template. Students will practice Project Management by working in teams to decide on energy saving projects and actions they can take at their school, and then identity discrete tasks needed to implement each project. Student teams work together to assign responsibility for the management of each task, and come up with target dates for implementation. The class has the option to implement their Action Plan while participating in an Energy Conservation Competition, hosted by SEI. This gives students the chance to be leaders in their school community and measure the actual impact they have on their school's energy usage.

Unit 4: Solar Water Heating (~7.5 hours)

This unit guides students through the steps of designing and building a solar hot water collector. Students gain an in-depth understanding of science of heat transfer, water heating efficiency, and design considerations. These topics are used as a basis for discussing the benefits of transitioning to more efficient and sustainable water heating. Students experiment to determine materials with high insulation properties and high solar radiation absorption factors. Then, students design and construct a solar water heater collector.

Unit 4 Key Assignments

Assignment 1: Investigating Thermal Conduction and Insulation
In this lab, students test a variety of materials to determine which will absorb the most heat and melt an ice cube the fastest in the sun. This activity gives students initial ideas to apply to the solar water heater that they build later in the unit.

Assignment 2: Water Heater Efficiency Calculations
Students learn how to calculate, energy, cost, and CO_2 savings from switching to a more efficient water heat. Students use these calculations to make the case for replacing a conventional water heater with a solar water heater..

Assignment 3: Building a Solar Water Heater
Students build a solar water heating collector based on guides provided or using their own designs. There is also the option to utilize iterative design to improve their collector to be tested multiple times.

Unit 5: Non-Renewable Energy Sources (~7.5 hours)

Students begin to explore the differences between various energy sources and their social, economic, and environmental impacts, including the effects on Earth's climate systems. They become familiar with our most common sources of energy, fossil fuels, and dive into nuclear power technology and production, including fission and fusion processes and the environmental impacts of nuclear through provided supplemental readings, articles, and videos, as well a final research paper.

Unit 5 Key Assignments

· **Assignment 1: Energy Sources Pros & Cons Presentations**
In small groups, student use the Internet to research the pros and cons of an energy source: coal, natural gas, solar photovoltaics, wind, hydropower, geothermal energy, biomass and biofuels, or nuclear. The groups will use a handout to guide them in their research to consider the environmental, economic, and social impacts of the energy source, including how it is mined or harvested; how it is transported and used in a power plant; and how any waste from the power plant is disposed of or treated. Students may create a final visual presentation, such as a slideshow or poster, on non-renewable resources and the opportunities for our society to reduce environmental impacts when using these sources.

· **Assignment 2: Nuclear Fission Model**
In small groups, students will perform a hands-on activity using balloons and scissors to illustrate the concept of fission. After the balloons undergo "fission" they will release energy, which demonstrates how fission is used in generating electricity. This activity also touches upon nuclear waste and the importance of proper waste disposal.

·**Assignment 3: Nuclear Power Research Project**
Students synthesize information from recommended supplemental reading and videos over the week to write a research paper, using appropriate grammar, scientific language, and style, on how nuclear power is generated, through fusion or fission. The paper will analyze the pros and cons of the nuclear energy, and the expected challenges, innovations, and growth potential for nuclear power industry.

Unit 6: Renewable Energy (~33.75 hours)

Students are introduced to primary renewable energy sources. Students learn solar photovoltaic technology basics including the photoelectric effect, photovoltaic cells, and solar PV system configuration. They apply their knowledge of solar to design a residential solar PV system and build a solar-powered USB charger.

Students investigate and complete hands-on projects demonstrating the ability of solar, water, and wind, to be sources of renewable energy. Students perform a series of lab activities and design challenges, in which students compete to see which team can create the most energy productive and energy efficient renewable energy devices, including wind turbines, and waterwheels. Students evaluate the comparative environmental, economic, and social impacts of renewable energy sources in research papers.

At the conclusion of this unit students will debate energy source pros and cons and evaluate the energy sources they think should be part of the energy mix of the future.

Unit 6 Key Assignments

· **Assignment 1: Investigating Maximum Solar Power Production**
Students use mini-solar panels and multimeters to measure the power output of the solar panels given different variables, such as the tilt and orientation of the panels. Students graph their final data tables, and analyze the results to determine what the optimal site, tilt, and orientation for solar panels are in their location.

· **Assignment 2: Solar USB Charger Project**

The SEI Solar USB Charger project guides students through the process of building a solar USB charger. Students complete the construction of a solar USB charger, including the soldering of the wiring connections and construction of a case to hold their charger, which has the ability to charge any device with a USB connection, such as a cell phone. This project builds skills in electrical circuitry, design, and soldering skills, and provides a platform for thinking critically about the issue of energy storage.

· **Assignment 3: Wind Turbine Blade Design Contest**
In this activity students will engineer and test a variety of blade designs. Students will experiment with different materials and shapes for blade design, allowing them to generate electricity or lift weights. Students analyze which design creates the most power, and then evaluate the lab by answering questions and interpreting results with peers through class presentations.

· **Assignment 4: Hydroelectric Kit Lab**
In this activity students design a Hydroelectric system. Students first use a hand generator to observe the conversion of mechanical energy into electrical energy. Then, student teams design their own water wheel using basic building materials such as plastic spoons, foam cups, funnels, holding tanks, tubing, string, straws, or tape to engineer the most effective water wheel. Teams compete to implement the most effective design based on criteria e.g. the smoothest and most consistent rotation. Students learn how to maximize efficiency of hydropower through design.

· **Assignment 5: Ocean Power Research Paper and/or Presentation**
Students investigate ocean wave, current, and tidal energy technologies, which are emerging renewable energy sources. They compose a 3-page research paper and/or create a powerpoint presentation on wave, current, or tidal power technology, the status of the effort to bring these technologies to scale, the barriers to widespread adoption, and opportunities for innovation. The paper and/or presentation will show how waves, currents, or tides can generate electricity, present wave, current, and tidal energy technologies, environmental impacts (good and bad), cost competitiveness with other energy sources, challenges, and career/entrepreneurship opportunities in wave, current, and tidal power. Students learn both the qualitative and quantitative costs and benefits of ocean power to: our society, the environment, and the economy.

· **Assignment 6: Energy Source/Mix of the Future Debate**
In groups of three, students will choose or be assigned an energy source on which to deepen their expertise. Students work in teams to research their energy source and its pros and cons, environmental laws and regulations at a state and national level governing this source, and they will debate the merits of growing our use of their energy source with groups representing the benefits of other sources. Student teams will then collaborate to design an ideal mix of energy for their utility by combining economic, environmental, technological, and reliability considerations to deliver electricity that is as clean, affordable, and reliable as possible to their community. The energy mix of the future project deliverable can be a Powerpoint presentation, research paper, or poster presentation. This provides students with a chance to think critically about our energy source choices and practice public speaking, as well as analyze the complex social, environmental, and economic impacts of energy sources.

Unit 7: Green Transportation (~15 hrs)

In this unit, students investigate comparative potential energy sources to power transportation vehicles including biodiesel, solar, and hydrogen fuel cells conversion through hands-on projects. Students will examine the ways that transportation policy and planning influence the environmental and societal impacts of how people and goods travel from one destination to another.

Unit 7 Key Assignments

· **Assignment 1: Making Biodiesel**
Students will learn from the SEI Green Transportation Certificate about the process of manufacturing biodiesel on a commercial level through recommended videos, and then make their own mini-batches of biodiesel in the lab. Students will review key safety information, and then demonstrate how fresh or waste vegetable oil can be mixed with lye and methanol to make a biodiesel fuel. During the lab, students observe the varying viscosity of heterogeneous mixtures that can occur due to chemical reactions.

· **Assignment 2: Making Hydrogen - Electrolysis Experiment**
Students demonstrate how electrolysis splits water to make hydrogen gas fuel through a hands-on lab, where they create electrodes with aluminum foil, and use a solar panel or battery to perform electrolysis.

· **Assignment 3: Solar Car Design**
This design competition activity starts with a simple solar car kit. Students begin with the basic materials provided, including pulleys, a solar panel, a motor, and wooden wheels, to design a basic solar-powered car. Students can then use whatever extra materials they want to customize and increase the effectiveness of their solar cars. To test their designs, students compete in a solar car race. If time permits, students can design new cars based on the observations they make during the race.

Unit 8: Energy, Environment & Utilities Careers (~7.5 hrs)

Students explore the wide variety of career and higher education opportunities and pathways in the Green Technology field. Students analyze their soft and hard skills, and start to develop a suite of professional resources, including a resume, cover letter, and job search and interview skills. As an optional extension to this unit, students can do a deeper dive into a specific green career through an informational interview, job shadow, or professional panel.

Unit 8 Key Assignments

· **Assignment 1: Labor Market & Skills Assessment**
Students will assess their own interest and fit for different jobs within the green technology field. Using the SEI Green Career matrix, which describes green technology career opportunities, including key responsibilities, required skills, education/experience needed, and average salary, students will review the matrix and research career options that might be of interest to them. Student then select two jobs and complete the SEI Skills Assessment Worksheet, which helps students to assess their interest in and fit for the job they have chosen and to inform their plan for pursuing this goal.

· **Assignment 2: Resume & Cover Letter Writing**
Using the tools and templates provided within the SEI curriculum, students will practice professionalism and strategic communication and prepare for their job search by developing a resume and cover letter for an

actual position. Students will begin filling in their resumes, following a group discussion about the skills and experience that they now have as a result of the different labs and projects they completed in the Introduction Green Technology course. Students will then find and research a job posting for a position of interest in their region and develop a cover letter that connects the experiences in their resume to the specific requirements of the posting.

Unit 9: Ecological Economics and Climate Policy

(~7.5 hours of instruction)

Students learn about key concepts in economics, including externalities and the tragedy of the commons, in order to better understand how economics is related to climate change. They research and discuss current climate-related policies through the lens of economics, and debate about each policy's pros and cons. They conclude by learning about climate-related policies in California and at the federal level, and applying their knowledge to create a personal political action plan.

Unit 9 Key Assignments

- **Assignment 1: Pros and Cons of Market-Driven Climate Policies**

In this assignment, students will be assigned to research the pros and cons of one of three market-driven climate policies currently in existence. Students will use their research to prepare for a fishbowl-style in-class discussion, which will provide students the opportunity to highlight the major advantages and disadvantages of each policy they researched. Due to the fishbowl style, all students will be able to learn about the pros and cons of each policy.

- **Assignment 2: Personal Political Action Plan**

Students will apply their knowledge of ecological economics and existing climate policy to take political action. They will research an issue related to climate policy, then generate a list of elected officials who have influence on this issue, as well as a list of nonprofit/nongovernmental organizations that center their work on climate public policy. Students will write a 1-2 page personal political action plan outlining why their chosen issue is important to them, what specific actions they want to see taken by elected officials, and what actions they personally can take to advocate for this policy. Finally, students will take action by writing a letter to an elected official, volunteering with a relevant organization, attending a meeting/event related to their issue, and/or by following political influencers/advocacy groups on social media.