sei STRATEGIC ENERGY INNOVATIONS

Grade: 9-12

Version 1

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Energy and Environmental Design

A G-Elective course where students complete more in-depth projects related to sustainable design, energy efficiency, and renewable energy.

Energy and Environmental Design Course Outline & Unit Descriptions

The SEI Energy and Environmental Design course is year-long course in which students will complete more in-depth projects related to sustainable design, energy efficiency, and renewable energy. With Introduction to Green Technology, this course offers complete coverage of California Technical Education standards for the Energy, Environment, Utilities industry sector - Energy and Power Technology Career Pathway. Students will conduct the following projects:

- Develop a Zero Net Energy Plan for your school: Utility bill analysis, Conservation Action Plan, Energy Audit report and School Solar Design project. Present to School Board.
- Solar Installation Projects: ground-mounted system and/or residential rooftop system
- Building a residential circuit
- Evaluating the applications of energy storage
- Designing a green building

The course is supplemented by suggested field trips and internships in the energy and environmental design field. Students have the option to present their projects at an Energize Schools High School Green Careers Conference.

Unit 1: Introduction to Sustainable Design (~9 hours)

In this Unit, students will be introduced to sustainability, climate change, and sustainable design as a framework for understanding the rest of the course. They will define sustainability and use their definition to examine their own behaviors in order to identify opportunities to become more sustainable. They will analyze climate data and discuss the impacts of climate change, learn about the science of climate change, and learn about the ways in which different behaviors contribute to this problem. Finally, students will explore concepts in sustainable design, including Zero Net Energy, as they prepare to embark on the rest of the course.

Unit 1 Key Assignments

Assignment 1: Exploring Home Energy Use

- Students examine their home energy bills to understand their monthly energy usage. They will hypothesize about what their biggest energy users are in their home, and brainstorm ways to reduce their energy use at home.

Assignment 2: Strength of the Evidence

- In groups, students will examine graphs that show different types of evidence for the changing climate. They will think critically together about what their evidence indicates,

then synthesize and share their evidence with the rest of the class. There are also several options for further research into the pieces of evidence, which can culminate in a paper or presentation.

Assignment 3: Carbon Footprinting

- This activity helps students to investigate their contribution to the increasing concentration of carbon in the oceans and atmosphere, and what behaviors contribute most to their footprint. Students will complete a questionnaire and fill in their behaviors on a form that will help them take stock of their behaviors in order to understand the size of their personal carbon footprint.

Assignment 4: Floor Plans

- Students will complete a floor plan design of an area of their school. This will help students become comfortable completing an architectural drawing, a skill that they will utilize throughout the rest of the course.

Assignment 5: Zero Net Energy Case Study

- Students will read case studies of zero net energy building to enhance their understanding of the concepts of zero net energy. They will also take note of ideas that they would like to apply to their own zero net energy proposal that they will complete later on in the course.

Unit 2: Electrical Grid (~13 hours)

Students are introduced to key energy system concepts, including energy policy, energy sources, power plant generation, distributed generation, transmission, energy efficiency, energy conservation, peak demand, and demand response. Students complete hands-on activities and labs that explore the fundamentals of the grid and electricity systems.

Unit 2 Key Assignments

Assignment 1: Local Fuel Mix

- In this activity, students use government data to find out what fuels supply the energy used in their home. They will consider the pros and cons of each of these energy sources during their research, and connect the impact of local electricity generation to their own personal carbon footprint. They compare these numbers to national averages and come up with ideas on how to reduce their energy usage.

Assignment 2: Building a Generator

- In this hands-on activity, students will enhance their understanding of how electricity is generated in a power plant. They will use a coil of wire, a magnet, and an ammeter to

explore how a magnetic field can generate electricity, and connect their experiment to electricity generation on a large scale.

Unit 3: Electrical Circuits (~15 hours)

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. Students will demonstrate their knowledge of Ohm's and Watt's Laws. Then, they will review safety standards regarding electricity and build a residential circuit from scratch.

Unit 3 Key Assignments

Assignment 1: Online Circuit Lab

- Using an online PhET simulation lab, students review basic electricity relationships, build virtual circuits following the instruction of schematic drawings, use an ammeter and voltmeter to take readings on circuits, analyze and explain the measurements and relationships in circuits, investigate basic electricity relationships in series and parallel circuits, and determine the resistance of common objects.

Assignment 2: Building an Electric Circuit

- Students construct a 2'x2' circuit board on plywood. Students will demonstrate their knowledge of the laws of electricity and the components of a circuit to design a board with a light switch, LED, and outlet that are part of a complete circuit. They will complete a safety training, use construction tools to construct a circuit, use a voltmeter to test the Ohms scale of different wires, and splice, connect, and ground wiring to complete a circuit build.

Unit 4: Energy Audit (~24 hours)

Students conduct a school-wide energy audit using the SEI Energy Auditing Certificate to identify opportunities for energy efficiency improvements and behavioral energy conservation. Students audit computers, appliances, lighting, lighting levels, drafts, temperature, HVAC, and motors. Then, students design and implement an energy conservation campaign on campus and develop an energy audit report for their school. Students acquire technical career skills in energy auditing, including measuring power use with a watt meter, determining lighting levels with light meters, and calculating energy savings by transitioning to energy efficient appliances, lighting, and mechanical systems. Through this project, students will earn an SEI Energy Auditing Certificate.

Unit 4 Key Assignments

Assignment 1: Classroom Plug Load Auditing

- Students use a watt meter to test audit plug loads (computers and appliances) in their classroom. Students will apply their knowledge of energy and power during this audit, as well as develop real-world energy audit skills. They will consider which of the plug loads they audited were the biggest energy users, and how they can apply efficiency or conservation measures to reduce this load.

Assignment 2: Classroom Lighting Audit

- Students will learn about various types of indoor lighting and determine what lighting types are in use in their school. They will calculate the amount of energy their lights are using, as well as conduct research and further calculations to determine potential energy savings from switching lighting types.

Assignment 3: Measuring Classroom Light Levels

- Using light meters students will examine several different lighting scenarios in their classroom to determine whether their room is typically overlit, underlit, or correctly lit. They will balance considerations of safety and productivity, and energy waste to determine an ideal scenario.

Assignment 4: Mechanical Systems Equipment Inventory

- Students will conduct a school wide audit of mechanical systems, including HVAC, water heaters, and motors. They will work with facilities and maintenance staff to conduct this audit and answer questions about how these systems are used to gain a more comprehensive understanding of school energy use.

Assignment 5: Final Data Collection & Reporting

- Students will use the SEI Energy Audit Tool in Excel to compile all of the data they collected during the school-wide audit. They will also conduct additional research in order to complete their school energy audit report and present their findings and recommendations.

Unit 5: Solar Installation (~7.5 hours + 1-2 days for a hands-on installation)

In this Unit, students will learn the fundamental considerations in conducting a solar site assessment and designing a rooftop system using CAD design programs. Students learn about solar science, sizing, siting, and design. They will apply this knowledge and gain hands-on technical experience by completing a residential rooftop and/or ground-mounted solar installation project. Students will also research and analyze growth and career opportunities in the solar industry, and think critically about some of the barriers and opportunities around widespread renewable energy generation and storage. Through the completion of this project, students will earn an SEI Certificate in Solar.

Unit 5 Key Assignments

Assignment 1: Solar installation project – rooftop or ground mounted

- Students participate in a hands-on solar installation project, either constructing a ground-mounted PV system at their school with the IBEW, or participating in a volunteer installation project on a low-income home through GRID Alternatives.

Assignment 2: Research paper on solar energy

- Students will write a research paper on solar power production, synthesizing information gathered from in-class presentations and supplemental reading and videos. Student papers will provide an analysis of the costs and benefits of solar energy production and development, considering both qualitative (i.e. aesthetics of solar fields/arrays) and quantitative social, environmental, and economic impacts.

Assignment 3: Skills assessment for renewable energy careers

- Students explore the market sectors and job opportunities available in the utility and renewable energy industries after obtaining new skills and knowledge by completing the SEI Solar Certificate. Students review an energy career matrix, explore the IREC solar career map, complete a self-assessment to aid in identifying their career interests, and speak with professionals in the field.

Unit 6: Zero Net Energy (~2.25 hours)

The School Zero Net Energy (ZNE) Design unit challenges students to redesign their school to produce as much or more energy than it uses. Students will analyze energy use at their school, culminating in a School Zero Net Energy Design Proposal and presentation that integrates energy efficiency, energy conservation actions, and renewable energy into their school designs. Students

set targets and identify strategies for achieving zero net energy through the three key vehicles of ZNE: efficiency, conservation, and on-site energy generation.

Unit 6 Key Assignments

Assignment 1: ZNE Proposal

- Students will be introduced to the template for their Zero Net Energy proposal. They will compile a report that includes an introduction, an analysis of energy use, energy efficiency recommendations, a conservation action plan, a school solar design, financial analysis, and a conclusion.

Assignment 2: ZNE Proposal Class Presentations

- Students will present their completed Zero Net Energy proposals to one another to receive peer feedback. They will practice in preparation for an optional presentation to their principal, the school board, or district facilities department.

Unit 7: Energy Storage (~7 hours)

Students will learn about the scientific principle of energy, various forms of energy, and how energy transfer works. They will explore the "duck curve", created by an increase in solar photovoltaic electricity sources, and how energy storage can address this challenge. Students will learn about existing energy storage technologies as they relate to the forms of energy explored in the first part of the lesson. They will delve into the chemistry of batteries and will test the conductivity of different metals to create the best lemon battery. Lastly, students will design and size a battery storage system that is compatible with their solar design from the previous unit.

Unit 7 Key Assignments

Activity 1: Energy Transfer Lab

- Students will observe energy transfer in action by building a series of simple circuits and analyzing the circuit components.

Activity 2: Lemon Battery Lab

- Batteries are an important means of energy storage. Students will build batteries out of lemons to become familiar with the concepts of oxidation and reduction. They will test different metals in their batteries to observe how different redox potentials can create higher or lower voltage batteries.

Activity 3: Solar Energy Storage Design

- Students will design an energy storage system for their solar photovoltaic system. Students will calculate the size for each of the components in the solar with energy storage system based off of the actual size of the solar system that they calculated.

Unit 8: Green Building (33-50 hours of instruction)

Welcome to the SEI Green Building Certificate. This certificate is an introductory course covering green building benefits, design and features, various existing programs and initiatives, and the implementation of green building measures to reduce social, environmental, and economic impacts. This curriculum contains content for six interactive modules, designed to take a minimum 33 hours of instruction, but can be scaled up. Through this Certificate, students gain skills directly applicable to the expanding green building and architecture careers, gaining an ability to identify and evaluate green building sites and features, and opportunities for improving the comfort and functionality of a building, while reducing resource consumption, operating costs, and improving indoor air quality.

Unit 8 Key Assignments

Assignment 1 - Green Siting Checklist

- Students will assess their school campus using a LEED-inspired checklist of green siting strategies and identify what green strategies their school is already practicing. Once the checklist is complete students will produce a proposal in which they suggest ways the school can improve by implementing and incorporating green practices through a renovation.

Assignment 2 - School Water Audit and Water Savings

- Students will work as a team to conduct a comprehensive water audit of the school. As part of this audit, students will examine the school's annual water usage, the average annual rainfall, and the square footage of the school buildings' roofs. They will then assess if the school can implement any of the following common green building approaches to water savings: low-flow fixtures, drip irrigation, xeriscaping, and rainwater collection.

Assignment 3 - Life Cycle Assessments of Building Materials

- Students will explore the lifecycle of a commonly used building material to better understand how green building designers decide which materials to include in their buildings or avoid. Students will map a resource pathway diagram for a commonly-used building material, lumber. After they will consider strategies that could reduce the embodied energy associated with the resource pathway of lumber.

Assignment 4 - School Indoor Air Quality

- Students will utilize a Indoor Air Quality checklist to access the indoor air quality of the entire school. Students will then create an informative poster with recommendations to improve the IAQ of the school. These posters will include the pollution source and the recommendation that targets the pollution source. Last, students will display their posters in a presentation to the principal or school administrator.

Assignment 5 - Innovation Pathways

- Students will either complete a case study of buildings that have gained LEED points by implementing innovation by design OR they will come up with their own innovation in a particular building feature, i.e. air quality, energy, or water efficiency.

Assignment 6 - Create a Rating System

- Students will explore other Green Building rating systems, such as Well Building Standard or Passive House, and using this information and knowledge gained in previous lessons will design their own Green Building Assessment. They will then compare their rating system to the LEED rating system and consider the pros and cons of each. They will make suggestions for what they think is lacking from the assessments they have researched. These suggestions will then be incorporated in the assessment of their final projects.

Assignment 7 - LCCA Calculator

- Students will learn more about life-cycle analysis by utilizing an LCCA calculator to identify the economic feasibility for selected green building measures. Once students have completed their analysis, they will present their findings to the class and lead a discussion about the economic feasibility of implementation of their measures.

Capstone Project: Green Building Design

- Throughout the unit, student groups have been researching green building strategies, solutions, and implementation practices. Now students will design their own green home using the parameters provided in the activity. Students will complete a poster presentation, 2D floor plans, and a 3D model to display the strategies and innovations they incorporated into their green home. These homes will be evaluated using the LEED rating checklist and suggestions from their own rating checklist created in a previous lesson.