California Education and the Environment Initiative

The EEI Curriculum cohesively integrates science and engineering practices (SEPs), content (disciplinary core ideas/DCIs), and crosscutting concepts (CCs) within its lesson procedures. This preliminary analysis intentionally teases apart the individual SEPs, DCIs, and CCs as a means of correlating the EEI unit with specific performance expectations; however, the EEI lessons weave these components back together.

High School Earth Science

E.4.c. The Greenhouse Effect on Natural Systems

"The Greenhouse Effect on Natural Systems" engages students in the study of Earth's systems by introducing evidence about California's changing climate and the variety of responses to this situation, including the state's recent history of global warming legislation. They have the opportunity to examine a wide array of data related to global patterns of climate change, including ice cores and the fossil record. An analysis of these data allows students to determine for themselves the relationship between increasing levels of greenhouse gases, such as atmospheric CO_2, and various human activities, including the use of fossil fuel. The unit guides students in an examination of the interactions among the geosphere, biosphere, atmosphere, and hydrosphere as the basis for evaluating the scope and scale of changes to Earth's natural systems that are occurring as the result of current trends in global temperatures. The unit concludes with an analysis of how political and public views about climate change have evolved as climate science research has advanced over the past several decades.

*The "Next Generation Science Standards" logo is a registered trademark of Achieve. Except for the State of California, neither Achieve nor the lead states and partners that developed the Next Generation Science Standards, was involved in the production of, and does not endorse, this product.

Next Generation Science Standards* Correlation with the California Education and the Environment Initiative (EEI) Curriculum

The EEI Curriculum is a great choice for transitioning to NGSS and contributes toward achievement of the performance expectations for the standards reflected in the Summary Chart below: HS-ESS2 Earth's Systems, HS-ESS3 Earth and Human Activity, HS-LS2 Ecosystems: Interactions, Energy, and Dynamics; and HS-ETS1: Engineering Design. Each EEI unit highlights a small number of performance expectations, science and engineering practices, disciplinary core ideas, and crosscutting concepts. Therefore, the EEI units contribute to students' overall achievement of the performance expectations by the end of a school year, where they will have had multiple opportunities to engage in all appropriate science and engineering practices, disciplinary core ideas, and crosscutting concepts. While EEI was designed to teach the 1998 California science standards to mastery, it reflects the real world interconnections in science and already incorporates many of the paradigm shifts reflected in the NGSS. To learn more about how EEI supports NGSS, visit http://californiaeei.org/NGSSGuides/.

	Next Generation Science Standards											
	HS-ESS2			HS-ESS3			HS-LS2			HS-ETS1		
	SEP	DCI	CC	SEP	DCI	CC	SEP	DCI	CC	SEP	DCI	CC
California Connection		✓	✓		✓	✓		✓	✓		✓	
Lesson 1 – Investigate the interactions that shape Earth's climate.		✓	✓		✓	✓		✓	✓		✓	
Lesson 2 – Examine the atmospheres of Earth, Venus, and Mars, and explore how Earth's atmosphere functions.	✓		✓	✓		✓			✓	✓	✓	
Lesson 3 – Consider the significance of greenhouse gases, and chart information.	✓		✓			✓	✓	✓	✓	✓	✓	
Lesson 4 –Interpret data from an ice core sample and solve a climate mystery.	✓	✓	✓	✓	✓	✓	✓		✓			
Lesson 5 – Analyze historical data, consider the concept of a carbon footprint, and write about global climate change	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
Lesson 6 – Explore the history of California's global-warming legislation.			✓				✓			✓	✓	
Traditional Unit Assessment		✓	✓		✓	✓		✓	✓		✓	
Alternative Unit Assessment			✓		✓	✓	✓	✓	✓		✓	

Correlation Chart Key

SEP (Science and Engineering Practices)
DCI (Disciplinary Core Ideas)
CC (Crosscutting Concepts)

EEI Unit E.4.c. The Greenhouse Effect on Natural Systems

Disciplinary Core Ideas Supported by this EEI Unit

HS-ESS2 Earth's Systems
HS-ESS3 Earth and Human Activity
HS-LS2 Ecosystems: Interactions, Energy, and Dynamics
HS-ETS1: Engineering Design

Performance Expectations	Suggestions for Using the EEI Unit to Support NGSS
HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.	Use this unit to engage students in an analysis of data showing the relationship between increases in atmospheric CO_2 and increases in temperatures. Have them analyze the relationship between decreases in polar ice, changes to sea level, and changes to Earth's surface temperatures.
HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	Use this unit to have students explore data from the study of fossils and ice core samples. Have them consider how the complex interactions between Earth's climate system (the geosphere, biosphere, atmosphere, and hydrosphere) are always causing changes in global temperatures, and that while some climate changes last less than a century, others may continue for millions of years.
HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.	Use this unit to have students discover that the study of past climate data helps scientists identify patterns of climate change and relate those changes to global levels of GHGs, thereby allowing them to make predictions about future climate changes.
HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	Use this unit to have students determine that while there have always been fluctuations in global temperatures, the increased amount of greenhouse gases (GHGs) that are resulting from human activities, including the increased rates at which humans are using fossil fuels, have accelerated global warming to unprecedented levels. Have students evaluate the scope and scale of the changes to natural systems that are occurring as a result of this global warming. Have them examine and critique how current state, national, and global policies and solutions are helping to mitigate global warming.
HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	Use this unit to have students determine that current scientific theories suggest that today's rise in overall global temperatures are caused by human activities, including the release of GHGs, and that efforts to develop policies that will establish and enforce quantitative criteria for limiting the output of GHGs may be ignored or only partly implemented as a result of several factors including societal needs and wants.

Science and Engineering Practices (SEPs)	Suggestions for Using EEI to Support SEPs	Disciplinary Core Ideas (DCIs)	Suggestions for Using EEI to Support DCIs	Crosscutting Concepts (CCs)	Suggestions for Using EEI to Support CCs
Developing and Using Models (HS-ESS2-4)	Use the unit to have students analyze models to better understand the greenhouse effect and to examine a variety of GHG sinks and reservoirs (Lessons 2 and 3). Have students examine models that provide the basis for evaluating the relationships among levels of CO_2, methane, and temperature (Lessons 4 and 5).	**ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2)	Use the unit to have students analyze evidence that changes to Earth's climate system have caused climate change over time, some of which can be sudden, such as volcanic ash clouds, and some of which can be very long-term, such as plate tectonic cycles (Lesson 4).	**Cause and Effect (HS-ESS2-4)**	Use the unit to have students consider evidence from the fossil record, ice core samples, and tree ring analysis which indicates that increased atmospheric levels of GHGs correlate with higher global temperatures (Lessons 1, 4, and 5). Have students analyze case studies on carbon sinks to determine the cause and effect relationships between human activities, such as industrial and agricultural development, and the effects of increased levels of GHGs in natural systems (Lesson 3).

Science and Engineering Practices (SEPs)	Suggestions for Using EEI to Support SEPs	Disciplinary Core Ideas (DCIs)	Suggestions for Using EEI to Support DCIs	Crosscutting Concepts (CCs)	Suggestions for Using EEI to Support CCs
Analyzing and Interpreting Data (HS-ESS2-2, HS-ESS3-5)	Use this unit to have students examine how scientists use data to learn about Earth's past through a study of fossil records and ice core samples (Lessons 2 and 4). Have students analyze and interpret data on global atmospheric carbon levels and temperature (Lesson 5).	**ESS2.D: Weather and Climate:** -The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2), (HS-ESS2-4)	Use the unit to have students explore Earth's climate system and how it involves complex interactions among the atmosphere, biosphere, geosphere, and hydrosphere (Lesson 1). Use the unit to have students determine how changes to Earth's atmosphere due to human activities, such as the burning of fossil fuels or clear-cutting of forests, increases the amount of GHGs in our atmosphere, is resulting in an increase of global temperatures (Lessons 1, 4, and 5).	**Stability and Change** **(HS-ESS2-2, HS-ESS3-5, HS-LS2-7)**	Use the unit to have students realize that climate changes caused by the interactions among Earth's geosphere, biosphere, atmosphere, and hydrosphere have occurred over time, and that some changes are irreversible, such as the extinction of plant and animal species (Lessons 1, 3, and 4). Have students determine that while Earth's climate changes over time, the climate and stability of Earth's temperature are due to the greenhouse effect (Lesson 2). Use this unit to have students examine how the quantity of greenhouse gases being released, as a result of human activities, is directly related to the scale and the significance of the effects on natural systems which result from increases in global temperatures (Lessons 1, 3, and 4)
Constructing Explanations and Designing Solutions (HS-LS2-7)	Use the unit to have students analyze how past connections between GHGs and rising temperatures support current theories that the global warming occurring today correlates with unprecedented levels of GHGs in our atmosphere (Lessons 3, 4 and 5). Have students analyze the history of scientific and engineering events and how they have resulted in policy and legislative decisions to be considered in California and worldwide (Lesson 6).	-Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4) **ESS3.D: Global Climate Change:** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3–5)	Use this unit to have students realize that through the study of a variety of data on climate change, scientists are able to better predict how the global climate will change in the future and make research-based recommendations about how to mitigate these effects (Lessons 4 and 5).		
Asking Questions and Defining Problems (HS-ETS1-1)	Use the unit to have students analyze the underlying causes for global warming in order to define the problems needing to be addressed, such as carbon footprints created as a result of everyday decisions (Lessons 3 and 5). Have students analyze several of the solutions proposed to help mitigate global warming and consider the real-world reaction to some of these proposals, such as the United States rejecting the Kyoto Protocol in 2001 (Lesson 6).			**Scale, Proportion, and Quantity** *(No Associated Performance Expectation)*	Use this unit to have students analyze the interactions and interconnections of Earth's natural systems including the climatic system, and how they influence one another. Have students consider the role of systems models, such as the models that demonstrate the relationship between increasing levels GHGs and rising global temperatures, in helping scientists make predictions about what may occur as the result of further increases in the levels of GHGs (Lessons 1-5).

Science and Engineering Practices (SEPs)	Suggestions for Using EEI to Support SEPs	Disciplinary Core Ideas (DCIs)	Suggestions for Using EEI to Support DCIs	Crosscutting Concepts (CCs)	Suggestions for Using EEI to Support CCs
		LS2.C: Ecosystem Dynamics, Functioning, and Resilience ...anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)	Use the unit to have students analyze the potential impact of global warming on ecosystems, such as how changes in climate affect water distribution and agriculture in California (Lesson 1). Have students consider how human caused changes to carbon sinks can contribute to the rise of GHGs in our atmosphere, hydrosphere, geosphere, and biosphere, thereby affecting the health of organisms living within various natural systems (Lesson 3).	**Scale, Proportion, and Quantity** *(No Associated Performance Expectation)*	Use this unit to have students examine how the quantity of greenhouse gases being released, as a result of human activities, is directly related to the scale and the significance of the effects on natural systems which result from increases in global temperatures (Lessons 1, 3, and 4)
		ETS1.A: Defining and Delimiting Engineering Problems: Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)	Use the unit to have students consider the need to limit the release of GHGs into natural systems (Lessons 1, 2, and 3). Have students examine the challenges resulting from global warming and analyze the effects that engineered solutions for reducing GHG emissions may have on individual communities and human societies (Lessons 5 and 6).	**Systems and System Models** *(No Associated Performance Expectation)*	Use this unit to have students analyze the interactions and interconnections of Earth's natural systems including the climatic system, and how they influence one another. Have students consider the role of systems models, such as the models that demonstrate the relationship between increasing levels GHGs and rising global temperatures, in helping scientists make predictions about what may occur as the result of further increases in the levels of GHGs (Lessons 1-5).
				Influence of Science, Engineering, and Technology on Society and the Natural World.	Use the unit to have students evaluate how new technologies, such as the internal combustion engine, may have a significant influence on natural systems, some of which were not anticipated, such as the burning fossil fuels contributing to global warming (Lessons 3, 5, and 6). Have students realize that when new engineering solutions are evaluated, it is important to consider the complete array of costs and benefits, including both the effects on earth's natural systems and human social systems (Lessons 3, 5, and 6).