Home Energy

Unit 2 Overview

We build science curriculum that inspires students to design a more sustainable world.

Unit 2 Home Energy

Introduction

CHALLENGE
Redesign your home to conserve energy.

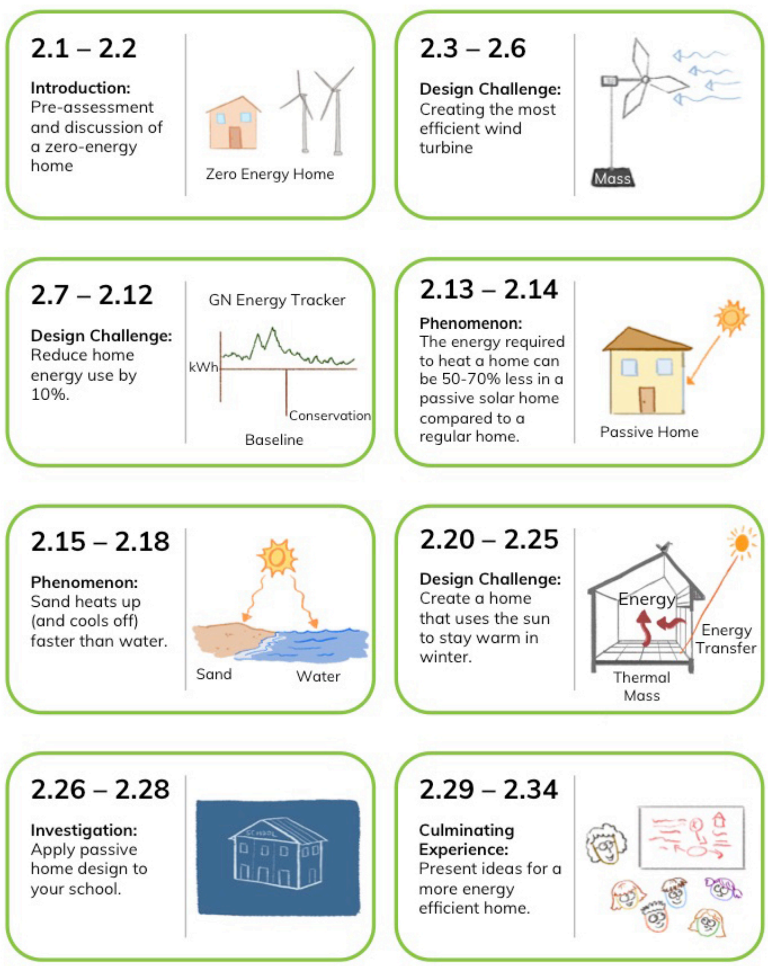
SCIENCE METHODS
Use engineering design concepts to design, create, and test a home energy conservation plan.

CULMINATING EXPERIENCE
Present on the ideas for a more energy efficient home.

Unit Storyline

This unit provides students with practical experience designing solutions to reduce energy use in their homes, using a zero-energy home as the enduring phenomenon. Students will employ engineering design approaches, combined with concepts of heat transfer, to design, test, and build models that represent elements of a zero-energy home. These experiences will inform students' recommendations for how to make their own homes more energy efficient.

This storyline graphic includes the lesson numbers of the primary phenomena, design challenges, and other learning experiences in this unit.



Unit Roadmap

Students begin the unit by creating their own wind turbines through an engineering design challenge. Later on, they study energy use in their own home (with their family) and this design challenge lasts the entire unit. Students will also study the design of a home, as they look into passive solar homes and how the orientation of windows and the use of thermal mass can affect energy use. A typical home requires more than 50 kWh of energy per day. A zero-energy home uses 0 kWh of energy when averaged over a year. It's a big difference, and during this unit, students will study the three main systems involved. Each of these themes is highlighted in the image below, and as the unit unfolds, students are referred to this image as a roadmap for what they've learned and where they are going.

Science Background

Designing Effective Climate Solutions: The climate is changing, and scientists have identified that the major contributor to its warming is the emissions of heat-trapping gases like climate carbon dioxide (CO_2). If carbon emissions continue at the same rate over the next few decades, life on this planet will become more difficult and challenging for people in every country of the world. However, if we can significantly reduce emissions, we can stabilize the climate so humans can better adapt to its changes with fewer negative impacts.

So, we have a real problem, and some of the best minds in the world are working to figure out a solution. How can we support 7 billion people with clean air, clean water, and reliable energy without damaging the climate? This problem will not be solved overnight—it represents one of humanity's greatest challenges. Let's start thinking about how engineers solve problems and how we can use these techniques to solve problems related to the changing climate.

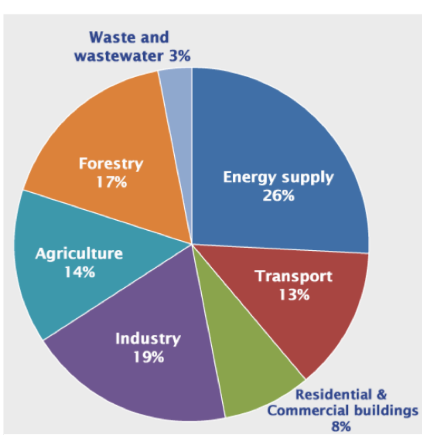


Fig. 1. Global greenhouse gases by source (IPCC 2007)

Science in Action

Designing solutions to reduce climate change requires data such as Fig. 1. This chart provides estimates of the sources of global greenhouse gases. Engineers can use this information to design new ways to provide the same services with lower greenhouse gas emissions. Your students can use charts like this to develop their own areas of climate solutions, as each source area is a major part of our society and economy.

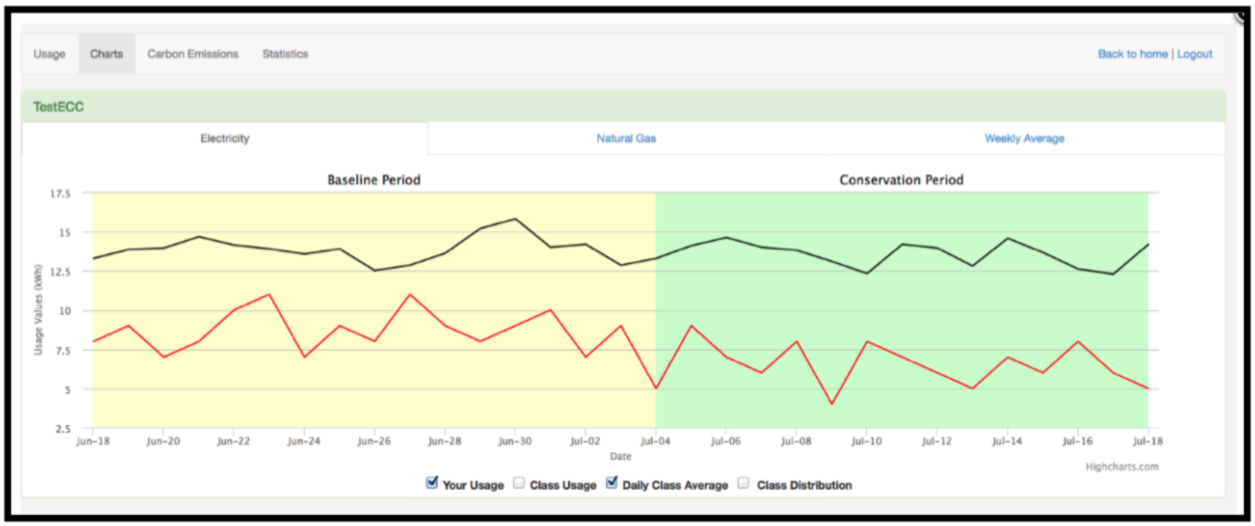
Green Ninja Connections

Green Ninja Story

The mission of this unit is for students to redesign their homes to reduce carbon emissions. Green Ninja introduces the unit and challenges students to be creative and smart when designing their solutions. Students will develop an understanding of energy use through videos, hands-on activities, and the Green Ninja Energy Tracker.

Green Ninja Energy Tracker

The Green Ninja Energy Tracker is an online tool that allows you and your students to monitor and track their home energy use (electricity and natural gas) over a period of time. You can monitor individual students and classroom averages, while students can see their own data and the data of their classmates (presented anonymously).



This figure shows one of the views from the Energy Tracker showing both the baseline period (before any design changes) and the conservation period (when students are implementing their designs). The individual student's data is shown in red, while the classroom average is shown in black.

Home to School Connections

Green Ninja curriculum connects classroom learning to everyday experiences in the home. It also provides many ways for parents to stay connected to the classroom. This unit is all about reducing energy use in the home. This theme opens the door to connect classroom learning with the personal lives of students.

Specific opportunities for parent involvement:

- Students use data from their home “smart meters” to understand how their families use electricity. Many parents will be interested in learning how their smart meters work and what the smart meters can reveal about usage.
  - Lesson 2.7 Introduction to Smart Meter Data Collection - Lesson 2.9 Power Meter Activity Part II
- Parents and students can work together to track changes in their home energy usage.
  - Lesson 2.10 The Green Ninja Energy Tracker - Lesson 2.13 Using the Sun to Stay Warm and Cool
- Parents can help students gather materials for models built in class.
  - Lesson 2.22 Home Design Prototype Part III - Lesson 2.24 Home Design Prototype Part V

Specific opportunities for parents to monitor student progress:

- Parents can be invited to class to see models and hear students present their insights about passive solar heating.
  - Lesson 2.25 Home Design Wrap-Up & Energy Tracker Check-In
- Students present their recommendations on making their school buildings more solar-efficient. Parents can be invited to class to hear these presentations. Alternatively, videos of the presentations can be shared with families.
  - Lesson 2.28 School Redesign Part III

Prior Knowledge

Students build on the knowledge they gained from grade 5 when they study **Earth’s place in the universe and relationships between the Sun and Earth (ESS1)**. The scope of this unit does not intend to cover this core idea; however, it is important that students at least see a model of why there are seasons on Earth. This allows them to begin to make connections between the relative positions of the Sun and Earth and the differences humans experience here on Earth in terms of temperature and length of day throughout the year. For energy, students know that **matter is made up of particles too small to be seen** (3-5 **PS1.A**). Students also understand that when thermal energy (heat) is added to a material, it gets warmer, and its temperature can be measured with a thermometer. To build on this knowledge, students carry out an investigation to determine the factors that affect how materials warm up. This knowledge helps in selecting materials for a passive solar home. Based on this investigation, students engage in using engineering design approaches to create the most effective designs possible and build upon grade 5 knowledge more deeply. The opportunity to expand on this exists for the overall unit while students “develop questions...and define the problems” **(ETS1.A)** about their families’ home energy usage. Similarly, students work on **designing, testing, evaluating, and redesigning (ETS1.B)** three different types of **models** (a wind turbine, a passive home, and a home energy conservation design) to **optimize (ETS1.C)** their efficiency.

Assessment

Unit 2 of the Green Ninja Grade 6 curriculum covers several different performance expectations in the Earth, Space, and Physical Sciences, as well as Engineering, Technology, and Applications of Science, and offers a variety of assessments for you to determine how well students combine the three dimensions of NGSS in order to understand the phenomena and solve the problems presented. The unit begins with a pre-assessment designed to give you information about your students' progression in their understanding of energy. Some of the questions challenge students to extend their understanding and give insight as to how well they identify **proportional relationships (CCC-3)** between **energy (PS3.A)** and temperature. The first two lessons of the unit provide instruction and opportunities for you to use the pre-assessment to gauge students' understanding as well as to identify their misconceptions.

Lesson 2.10 The Green Ninja Energy Tracker and Lesson 2.11 Energy Tracker Design Challenge: Data Analysis Practice offer you a formative assessment as students access and analyze data about their home energy use. Students will have time to explore and identify **patterns (CCC-1)** as well as to come up with ideas as to what caused the patterns. The format of the lesson, with students engaging in a think-pair-share, gives students the freedom to bounce ideas around and to share them with the class. This not only gives other students insights, but gives you valuable information on how well students **identify cause and effect relationships (CCC-2)** between energy-use habits and the data collected and use this to **develop possible solutions (ETS1.B)** as they apply engineering and design principles to reduce their home energy use.

After investigating thermal mass and solar orientation, in Lesson 2.21 Home Design Prototype Part II, students are given a question designed to gauge how well they are connecting the crosscutting concept of **scale, proportion, and quantity (CCC-3)**with the core idea of **conservation of energy and energy transfer (PS3.B)**. This gives you an opportunity to use students' responses and lead a class discussion in order to dispel misconceptions and prepare students for applying scientific ideas or principles to **design (SEP-6)**, construct, and test a passive solar building to meet an engineering design performance expectation **(ETS1.B)**. This particular project offers multiple measures of summative assessment as students produce an actual prototype and submit a report highlighting their design and results. The report is designed to give you evidence of students' three-dimensional learning as they show their understanding of **energy transfer (PS3.B)** by **constructing explanations and designing solutions (SEP-6)** and **planning and carrying out an investigation (SEP-3)** in order to track **energy transfer (CCC-5)** from the Sun with thermal mass in the prototype. Additionally, the report gives students an opportunity to formally **communicate information (SEP-8)**.

A key learning sequence in this unit extends learning as students apply the principles of **energy and energy transfer (PS3.B)** to redesigning their school by using passive solar home design principles. This activity differentiates learning by making it applicable and relevant to students' lives. The summative assessment for these lessons also offers differentiation as students are asked to create a digital presentation of their redesign. A rubric gives you the tools to assess how well students apply their knowledge of **energy and energy transfer (PS3.B)** to a new application, their school, and **design solutions (SEP-6)** and **communicate (SEP-8)** their ideas.

Access and Equity

This unit, with a focus on energy generation in the first part and energy usage in the second part, caters to a wide range of student groups due to the number of hands-on and engaging design challenges and the relevance to daily life. Students build and modify wind turbines; design, build, and test a passive solar home; and collect and interpret data on their own home energy use.

There are abundant opportunities for choice (a research-supported method of differentiation for EL learners, special-needs students, and students with disabilities, among others) in the design challenges and different avenues for engagement. Students are afforded multiple opportunities and means in which to convey knowledge: physical construction of an object such as a wind turbine or passive solar home; suggested school redesign with energy-efficient concepts orally presented to peers and guests such as school administrators or energy officials; written reflections of strengths and weaknesses of designs; and even videos of recommendations to a community to reduce energy usage. This encourages equity and access among all disadvantaged groups.

To help students in foster care, students living in poverty, and other students in unstable living environments, you may offer the option of tracking your personal home's or the school's energy usage if it will be difficult for them to acquire data of their own. You can also provide an example of average data that students can use as their own.

Many of the lessons in this unit are contingent upon participation in previous lessons. To foster equity and access throughout the design challenges, permit students to get ideas from others by arranging their work spaces for broad visibility and leaving materials in central spaces. Instead of providing answers for students, ask them to explain their problem and what they have tried. You can use questions such as "What if you...?" to encourage students to persist. When you observe students succeeding, especially females, students with disabilities, and EL learners, position them as an "expert" and suggest other students go to them for their expertise or have them circulate and provide help.

Engineering Connections

This unit has a number of engineering design challenges as students apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. During the various different series of lessons, students complete several hands-on engineering-related assignments, including:

- Build and redesign a wind turbine using readily-available materials.
- Learn how to read a home electricity meter.
- Analyze data to pinpoint opportunities for reducing energy consumption.
- Design, build, test, and optimize a model home that uses solar energy.
- Apply the knowledge gained in the solar-home project to recommend changes to school facilities.

Alignments to **ETS1-1** through **ETS1-4** are clearly identified in each lesson.

Resources

Outside Educational Resources
You may want to visit an architecture studio or tour a LEED building.

- Directory of top California architects: https://www.california-architects.com/en/profiles?char=A
- Architecture studio visit or building tour. For example: https://ecologistics.org/passive-solar-design-field-trip-to-cbd/
- Passive solar architecture examples in California: http://californiasolarcenter.org/city-list/

Supplemental Resources
Preview this thermal energy simulation prior to starting the Home Energy unit:

- https://phet.colorado.edu/en/simulation/energy-forms-and-changes

Here is a good summary of seasons and a system to maximize the amount of sunlight on a passive solar building:

- http://solarschoolhouse.org/solar-orientation-video/

Technology and Teaching

Technology is highlighted in this unit in a number of lessons. Students use a power meter to determine energy consumption of appliances in Lesson 2.8 Power Meter Activity Part I and Lesson 2.9 Power Meter Activity Part II. Students use the *Green Ninja Energy Tracker* software to enter and analyze their electricity use. Additionally, they use Infrared (IR) thermometers to investigate the thermal mass of materials in Lesson 2.17 Thermal Mass Investigation Part III. Although many students enjoy technology related to computer games and phones, similar technologies such as the IR thermometer can be employed to help them learn more about how the world works and how they can achieve their own goals. Using such instruments sparks students' curiosity and encourages them to wonder how these work and what science is being used. For example, students could use the IR thermometer to test for the most efficient mobile phone—the one with the lowest temperature, which might indicate the most efficient computing chip. Point out to students that technology can be used in different ways and is a tool to further learning. Using technology in and of itself, such as using a computer or iMovie, isn't the end goal. Fostering the use of technology for students to contextualize their learning and increase their understanding of science is the goal.

NGSS Standards

This unit has two key concepts: **Energy Generation and Energy Use (PS3.A)**. Students develop a scientific understanding of the value of renewable energy (e.g., wind energy) and the **influence of technological advances (ESS3.C)** in our society. This unit provides students with the opportunity to **investigate (SEP-3)** the **properties of different materials (CCC-5)** (e.g., thermal mass) and designs that would improve the **thermal transfer (PS3.B)** inside structures, such as a home, and how to benefit from natural energy sources, such as the Sun, to influence the energy production and temperature of a home. After students analyze energy transfer and use within a **small-scale (CCC-3)** system such as a home, they make connections to their own home's energy use, which will encourage them to **develop questions** of and **define the problems** (**SEP-1**, **ETS1.A**) about their family's energy use. In addition, they work on **designing (SEP-6)**, testing, **evaluating and redesigning (ETS1.B)** three different types of **models (SEP-2)** (a wind turbine, a passive home, and a home energy conservation design) to **optimize (ETS1.C)** their efficiency. Students **analyze (SEP-4)** their results to observe the **effects of their actions (CCC-2)**, showcase their models, and evaluate the designs of their classmates to **engage in arguments (SEP-7)** that help them discuss results and improve their models.

Unit Performance Expectations
ESS3-3, PS3-4, PS3-5, ETS1-1, ETS1-2, ETS1-3, ETS1-4

Common Core and CA ELD Standards

In this unit, a variety of opportunities exists for students to participate in collaborative discussions, write or follow scientific procedures, and collect and analyze data as they investigate ideas and methods to reduce home energy use. For example, students work together in a design challenge to create a more efficient wind turbine. As highlighted in Lesson 2.3 Building a Wind Turbine, this requires them to follow a multi-step procedure, which supports Common Core State Standards (CCSS) for English Language Arts (ELA)/Literacy and California English Language Development Standards (CA ELD). Student pairs have the opportunity to organize their findings and present them to the class in informal presentations in Lesson 2.11 Energy Tracker Design Challenge: Data Analysis Practice. In the culminating experience, students are provided with an oral-presentation guide to help them prepare for small-group presentations synthesizing their entire experience throughout the unit. That is highlighted in Lesson 2.34 Moving Towards Zero Energy: Final Student Presentations to support the standards of speaking and listening in CCSS for ELA/Literacy and CA ELD.

In terms of math content, students collect data and make calculations comparing various aspects of energy efficiency. In Lesson 2.7 Introduction to Smart Meter Data Collection, students are introduced to smart-meter technology and are empowered to take and interpret analog power meter readings. Lesson 2.8 Power Meter Activity Part I is highlighted as supporting Common Core State Standards (CCSS) for Mathematics of computing fluently with multi-digit numbers. In Lesson 2.9 Power Meter Activity Part II, students measure and then calculate the energy that various appliances use by multiplying the hours used by the power of watts. Students extend their analysis and calculate energy usage for a year and the cost of that energy to compare the efficiency of appliances. Also throughout the unit, students use the Green Ninja Energy Tracker to collect and analyze data on daily electricity (kWh) and natural gas (therms).

Common Core – ELA/Literacy
L.7.6, RST.6-8.3, SL.6.2, SL.6.4, SL.6.5, W.6.4, WHST.6-8.2, WHST.6-8.4, WHST.6-8.6

Common Core – Mathematics
MP4, MP5, MP7, 6.EE.A.2, 6.EE.B.7, 6.SP.A.1, 6.SP.A.2, 6.SP.B.5

CA ELD
P1.6.2, P1.6.5, P1.6.9, P1.6.10, P1.6.12

California's Environmental Principles and Concepts

This unit addresses four Environmental Principles and Concepts (EP&Cs). In Lesson 2.1 Introduction to Home Energy and Lesson 2.2 Wind Power Introduction, students develop an understanding of **Principle II, Concept B.,** that **People Influence Natural Systems**, while they are watching the *Karbon Kombat* video about the detrimental effects of nonrenewables on natural systems while seeing the benefits of renewables. Starting with Lesson 2.13 Using the Sun to Stay Warm and Cool, a major theme of this unit is reducing students' home energy usage as a design challenge. Through modeling passive solar design engineering, students become acquainted with **Principle I, Concept B.,** that **People Depend on Natural Systems**—utilizing the benefits of the Sun for engineering heating and cooling systems for homes. In Lesson 2.19 The Sun and Your Home, students continue **Principle 1, Concept B.**, and investigate solar orientation and how the Sun's angle can affect the heating and cooling of a passive solar building. Additionally, through various iterations of the unit challenge in Lesson 2.12 Energy Tracker Design Challenge: Planning, Lesson 2.18 Thermal Mass Wrap-Up & Energy Tracker Check-In, and Lesson 2.25 Home Design Wrap-Up & Energy Tracker Check-In, students learn **Principle V, Concept A.,** that **Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors**, while deciding on design factors that make use of renewable energy rather than greenhouse-producing nonrenewables. Furthermore, through these lessons, students develop an understanding of **Principle IV, Concept B.,** that **There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing Between Systems**, as they explore how heat from the Sun can be used from natural systems and can be harnessed for heating and cooling homes in human systems.

- Principle I – People Depend on Natural Systems
  - Concept B.
- Principle II – People Influence Natural Systems
  - Concept B.
- Principle IV – There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing Between Systems
  - Concept B.
- Principle V – Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors
  - Concept A.