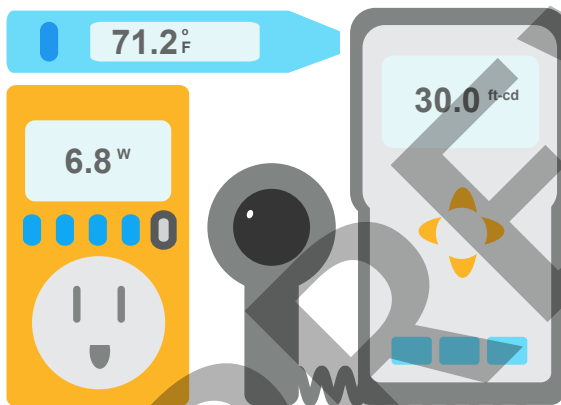


# Energy Audit Certificate



Perform a school energy audit and gain hands-on experience to develop skills and awareness in the energy auditing profession

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# Curriculum Matrix: School Energy Auditing Certificate

~36 hours of coursework

Module		Lesson		Schedule	Description
0	Intro	0	Introductions & Pre-Test	25 minutes	Introduce unit and give student pre-test.
1	Why is Saving Energy Important?	1.1	Sustainability: Problems and Opportunities	90 minutes	Intro to energy auditing: Why this is important work? What is the purpose of energy auditing? Students develop, analyze and discuss sustainability definitions and their personal carbon footprint. Students evaluate and compare home energy usage using the local utility's energy tool.
		1.2	Climate Change	225 minutes	Students explore, research, and discuss the causes and consequences of climate change.
2	Fundamentals of Energy	2.1	Energy Sources	135 minutes	Our energy choices have a significant impact on climate change. Students identify renewable vs. non-renewable sources of energy and explore their pros and cons.
		2.2	Electricity Grid	45 minutes	Students identify the power mix used by their utility to produce electricity, and understand the environmental impacts of electricity production as a context for the importance of energy efficiency. Compare emissions factors for variety of utilities. Students will learn about the grid, peak demand, stages of electricity transmission, and inefficiencies in distribution.
		2.3	Energy & Power	45 minutes	Students learn to calculate power demand, energy consumption, energy costs, and greenhouse gas emissions of electrical devices.
3	Tackling Energy Waste: Appliances	3.1	Auditing Appliances	2.25 hours	Through hands-on assignments, students will conduct an energy audit of plug loads and calculate energy savings based on their recommendations. Students will also learn about appliance energy efficiency ratings and standards.
4	Tackling Energy Waste: Lighting	4.1	Auditing Lighting	2.25 hours	Students learn to identify inefficient lighting and to recommend appropriate lighting upgrades. Students will conduct a lighting audit, estimate energy and cost savings based on the implementation of their recommendations, and continue to develop an energy audit report.
		4.2	Lighting Levels, Lighting Controls, & Conservation Practices	90 minutes	

5	Tackling Energy Waste: Mechanical Systems	5.1	Draft Detection & Thermostat Audit	90 minutes	Students will act as detectives searching for unwanted air leakage and thermostat errors that result in wasted energy and uncomfortable indoor spaces in the school.
		5.2	Mechanical Systems Audit	6.5 hours	Students learn about the types of mechanical systems found in schools, their function, and rating systems including SEER and EER. Students learn to read rating labels on mechanical and electrical equipment to assist with identifying the year of manufacture and capacity. Students mechanical systems, including HVAC, pool pumps, commercial kitchens, building controls, water heating, motors, and renewable generation systems, where they exist.
6	Tackling Energy Waste: Conservation & Building Envelope	6.1	School-Wide Energy Audit	5.25 hour	Students will use the auditing skills they have developed throughout the Certificate to perform a school-wide walk-through audit of energy use.
		6.2	Rebates and Incentives	45 minutes	Students identify programs, rebates, and incentives that can assist the school with adopting their recommendations and integrate into their report.
		6.3	Energy Audit Report & Presentations	4.5 hours	Students complete their energy audit report and prepare to present to their school community and/or school board.
7	Green Careers	7.1	Green Careers	90 minutes	Students explore the market sectors and job opportunities available in the green economy after obtaining marketable skills and knowledge by completing this curriculum. Students will complete a self-assessment to aid in identifying their career interests, will develop job search skills and materials, and will then, ideally, speak with professionals in the field.
0	Conclusion	0	Post-test, Peer Evaluation & Next Steps	45 minutes	Students will take the post-test to evaluate learning retention and skills acquired through the training. Students and instructors share feedback.



## Lesson 4.1 Overview

### Estimated Time

2.25 hours

### Standards:

**NGSS:** HS-ESS3-2, HS-ESS3-4, HS-PS3-1, HS-ETS1-3

**CCSS:** *Math* HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3, HSA.CED.A.1, HSA.CED.A.4, HSA.REI.B.3,

*ELA Literacy* RST.9-10.3, RST.9-10.4, RST.9-10.7

**CTE:** Energy, Environmental & Utilities: 2.0, 2.3; 5.0, 5.1, 5.3; A8.0, A8.4

### Objectives:

 Students will be able to:

- Identify standard lighting types and their components
- Calculate energy consumption and cost to operate light fixtures
- Identify lighting retrofits and calculate energy savings based on the recommendations

### Handouts

- 4.1.1 Classroom Incandescent/CFL/LED Bulb Audit & Retrofit Recommendations
- 4.1.2 Classroom Linear Fluorescent Lighting
- 4.1.3 Classroom Exit Signs Audit

### Materials

- Smartphone with camera
- Computers with Internet
- Tape measure

### Additional Resources

- How Fluorescent Lamps Work: <http://home.howstuffworks.com/fluorescent-lamp2.htm>
- School T12 to T8 Retrofit Project: <https://www.energy.gov/eere/wipo/authorization-and-intergovernmental-programs-office>

## Lesson 4.1: Auditing Lighting

Lighting accounts for up to 11% of electrical energy consumption for businesses and commercial buildings and 7% of all electricity consumed in the United States.<sup>1</sup> In this lesson, we investigate lighting to identify measures and retrofits that can lead to significant energy savings. Through hands-on assignments, students will conduct a lighting analysis and calculate energy savings based on their recommendations.

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### KEY WORDS

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**Ballast:** A device that regulates the current going into fluorescent lamps

**Compact Fluorescent Light (CFL):** An energy efficient fluorescent light bulb used to replace traditional incandescent light bulbs

**Light Emitting Diode (LED):** A long-lasting lighting technology often that requires very little energy

**Linear Fluorescent Lamp:** Fluorescent light tubes common for interior overhead lighting in a school or office

**Luminaire:** The lighting industry's term for what is commonly referred to as a "light fixture." A luminaire consists of the housing, power supply (ballast or driver), "lamp" or light source, and optical components, such as reflectors and lenses.

**Rebates/Incentives:** Money or credit offered by utilities, state, or federal governments to help offset the initial investment for the installation of energy efficiency measures

**Walk-through:** The portion of an energy audit in which the auditor observes and collects data on the loads in a home or building

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<sup>1</sup> <https://www.eia.gov/tools/faqs/faq.php?id=99&t=3>

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## PREPARATION

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- Prior to this lesson, review background material on lighting and lighting retrofits. Read through the handouts and become familiar with calculating lighting energy consumption. Gather materials required for the lesson (see the Materials Matrix in the Introduction Module).
- Prepare to discuss typical lighting types found in overhead lighting and exit signs in buildings. It would be helpful to ask a custodian for replacement lamps. Then, students can record information directly from the bulbs. Fluorescent lamps are fragile and contain mercury, so be careful when handling. Fluorescent bulbs must be recycled at a proper recycling or hazardous waste facility. If the school doesn't already have designated recycling containers contact the local municipal disposal agency or search these websites to find a recycling facility:  
<https://www.epa.gov/cfl/recycling-and-disposal-cfls-and-other-bulbs-contain-mercury> OR  
<http://search.earth911.com/>.
  - In the case of a broken bulb, proper ventilation is needed. Have people and pets leave the room and air out the room for 5-10 minutes by opening a window or door to the outdoor environment.
  - Shut off the central air heating/air-conditioning system, if you have one.
  - Scoop up glass fragments using stiff paper or cardboard. Use sticky tape, such as duct tape, to pick up any remaining small glass fragments and powder. All fragments should be sealed in a plastic bag before being recycled like intact bulbs.
- Obtain an incandescent lamp and its more energy efficient counterpart, the compact fluorescent light bulb (CFL). It will also be informative for the class if the instructor (or custodian) is able to remove the cover of an exit sign to show the lamps inside the fixture.
- Print the following handouts:
  - Classroom Incandescent/CFL/LED Bulb Audit & Retrofit Recommendations – one per student
  - Classroom Linear Fluorescent Lighting – one per student
  - Classroom Exit Signs Audit – one per student

### Recommended Daily Lesson Breakdown:

- Day 1: Lighting Fixtures
  - Setting the Stage: Lighting Energy Consumption
  - Setting the Stage: Incandescent, CFL, and LED
  - Activity 1: Classroom Incandescent, CFL, and LED Survey
- Day 2: Classroom Lighting Audit
  - Setting the Stage: Types of Lighting Fixtures

- Activity 2: Classroom Lighting Audit
- Days 3 and 4: Exit Sign, Exterior Lighting, and Gym Lighting Audit
  - Setting the Stage: Exit Signs, Gym, & Exterior Lighting
  - Activity 3: LED Exit Signs, Exterior Lighting, and Gym Lighting Audit

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## SETTING THE STAGE: LIGHTING ENERGY CONSUMPTION

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- In 2014, about 412 billion kWh of electricity were used for lighting by the residential sector and the commercial sector, including schools, in the United States. This was about 15% of the total electricity consumed by both of these sectors, and about 11% of total U.S. electricity consumption.<sup>2</sup>
  - To put 412 billion kWh in perspective, the greenhouse gas emissions from producing that amount of electricity are equal to almost 60,000,000 cars driven for a whole year!
- Inform students they will be conducting a lighting audit in the classroom first to learn and test their auditing techniques. Later in the course, they will conduct a walkthrough lighting audit of the school to make recommendations for conservation and retrofits.
- The classroom lighting audit will cover lighting fixtures such as incandescent, compact/linear fluorescent (CFL/LFL), and light emitting diode (LED) types as well as exit sign lighting. In the next section, students will learn about different types of lighting as well as how to identify them in the context of a lighting audit.

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## SETTING THE STAGE: INCANDESCENT, CFL, AND LED

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- Incandescent light bulbs are sometimes used in schools. They can be found in desk lamps, floor lamps, exit signs, and sometimes even in ceiling fixtures.<sup>3</sup>
  - In the most basic form, incandescent lighting is still much like that invented by Thomas Edison 140 years ago. In the light bulb, electricity flows through a thin wire called the filament. The resistance against electricity flowing through the filament causes it to heat up and glow.
  - The light bulb has no oxygen in it, so the filament does not catch fire or burn. It does, however, lose atoms from the intense heat and eventually weakens and breaks, causing the light bulb to burn out.
  - Although the incandescent offers some of the best light quality at a low price, it is the least efficient: only 5-10% of the energy consumed by an incandescent bulb produces light; the rest is given off as heat.



Incandescent Light Bulb

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<sup>2</sup> <https://www.eia.gov/tools/faqs/faq.cfm?id=99&t=3>

<sup>3</sup> [https://en.wikipedia.org/wiki/Incandescent\\_light\\_bulb](https://en.wikipedia.org/wiki/Incandescent_light_bulb)

- The lifespan of an incandescent lamp is short as compared to other technologies, causing its maintenance costs to be relatively high. Incandescent lamps last approximately 1,000 hours<sup>4</sup>, which can mean multiple bulb changes per year for a lamp that is often in use, like an exit sign.
- **Compact fluorescent light (CFL) bulbs** use the same technology as linear fluorescent lamps, but they are designed to fit into lamps and other fixtures where incandescent light bulbs are commonly used.
  - In a fluorescent lamp, light is created by sending electricity through a gas. This produces visible light, but also some ultraviolet light, which is invisible to the human eye.<sup>5</sup>
  - To make the ultraviolet visible, the inside of a fluorescent light bulb is coated with phosphors, which absorb the ultraviolet light and change it to visible light. This brightens the light.
  - The electricity needed by the lamp is converted and controlled by a ballast.
  - Although CFLs cost slightly more than incandescent light bulbs, they save money in the long run because they use only one-fourth the energy of incandescent bulbs, they produce very little heat, and last 6 to 12 times longer<sup>6</sup>.
  - Fluorescent light quality is suitable for office and school lighting. The lamps are more energy efficient and have a longer lifespan than incandescent lighting.
- **Light Emitting Diode (LED) lamps** are comprised of an array of light emitting diodes which use solid-state electronics to create light.



CFL Bulb

- A LED is a light source which uses semiconductors and electroluminescence to create light. Electroluminescence happens when electrons are passed through certain materials, and the material emits light. Similar to a ballast, the electricity needed by the LED is controlled by a driver.<sup>7</sup>
- A typical LED consumes 80% less energy than a comparable incandescent bulb and 50% to 80% percent less energy than a comparable CFL.<sup>8</sup>
- LEDs contain no mercury, and a recent Energy Department study<sup>9</sup> determined that LEDs have a much smaller environmental impact than incandescent bulbs. They also have an edge over compact fluorescent lights (CFLs) that's expected to grow over the next few years as LED technology continues its steady improvement and becomes more cost-effective.



LED Light Bulb

<sup>4</sup> <http://energy.gov/energysaver/articles/how-energy-efficient-light-bulbs-compare-traditional-incandescents>

<sup>5</sup> Image Source: [http://farm2.staticflickr.com/1086/1393726309\\_287fc8d340\\_o.jpg](http://farm2.staticflickr.com/1086/1393726309_287fc8d340_o.jpg)

<sup>6</sup> <https://www.nachi.org/energy-lighting.htm>

<sup>7</sup> ImageSource: [http://commons.wikimedia.org/wiki/LED\\_lights#mediaviewer/File:Led\\_lamp.jpg](http://commons.wikimedia.org/wiki/LED_lights#mediaviewer/File:Led_lamp.jpg)

<sup>8</sup> <http://energy.gov/energysaver/articles/how-energy-efficient-light-bulbs-compare-traditional-incandescents>

<sup>9</sup> <https://www.energy.gov/eere/articles/study-environmental-benefits-leds-greater-cfls>



- From an energy stand point, LED lighting is versatile and energy efficient. Although the initial cost is higher than other light sources, the life expectancy is very long and the return on investment from energy and replacement savings makes upgrading to LEDs worth the initial cost.
- Maintenance and replacement costs are reduced because LEDs are estimated to have lifetimes between 25,000 and 100,000 hours<sup>10</sup>. Replacing incandescent light bulbs and CFLs with LEDs is a great way to save energy at your school!
- The development of white LEDs has helped LEDs gain popularity as a replacement for other white light sources. LEDs are currently commonly used for streetlights, indoor growing lights, traffic lights, and other lighting applications with long operational hours, and are increasingly being used to replace incandescent and fluorescent light bulbs as a cost-effective, bright, and quality alternative for overhead and task lighting.
- Compared to other lighting types, LEDs offer a variety of benefits. Some of these benefits include small size, long lamp life, low heat output, energy savings, and durability.<sup>11</sup> LEDs also come in many different colors, shapes, and sizes.
- More detailed information and discussion about the science behind LED technology is abundant on the internet. Visit <https://energy.gov/energysaver/led-lighting> for more LED facts.

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### ACTIVITY 1: CLASSROOM INCANDESCENT/CFL/LED BULB SURVEY

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- Provide a copy of the Classroom Incandescent/CFL/LED Bulb Audit & Retrofit Recommendations handout to each student (or to small groups). Explain that they are going to calculate the annual energy consumption and cost to operate the incandescent/CFL/LED light bulbs first in a scenario and then in the room in preparation to conduct this component of the audit for the school.
- Tips for supporting students with word problems: First, read the word problem with students and see if there are any questions. If the students are having trouble getting started on the word problem, ask them to:
  - Circle or highlight all of the important information or rewrite the important information elsewhere on the page.
  - Set-up and complete the equations one at a time.
  - When setting up the equations, use only the units instead of the numbers to figure out what units the final number will be in. Knowing the correct units, students can then go back and figure out the correct numbers to arrive a final answer.
- Have students calculate the scenario problems 1 and 2, and then discuss. Then, students will check to see if there are any incandescent light bulbs in their classroom.

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<sup>10</sup> <http://energy.gov/energysaver/articles/how-energy-efficient-light-bulbs-compare-traditional-incandescents>

<sup>11</sup> <http://energy.gov/energysaver/articles/how-energy-efficient-light-bulbs-compare-traditional-incandescents>