LESSON

Introduction to Personal Protective Equipment: Identification and Use (Lab)

BIG IDEA(S)

Some form of PPE is always required in every weatherization installation.

OBJECTIVES

Students will:

- Identify the basic components of PPE
- Identify what PPE is needed based on tasks undertaken
- Use a Materials Safety Data Sheet (MSDS) to identify hazards
- Demonstrate how to properly wear PPE

TASK LIST SUBCATEGORY

303 Demonstrate the use of Personal Protective Equipment (PPE)

305 Recognize and mitigate hazards (relevant to tools or materials to be used)

811 Prepare and maintain tools and equipment used for energy auditing and weatherization (Safety)

OVERVIEW

Some form of PPE is always required in every weatherization installation. This lab teaches the basics of PPE, what each component is used for and proper wear. One key component in safety is the Materials Safety Data Sheet (MSDS). These are used to alert installers of any potential hazards associated with the various materials.

STANDARDS

PA/SDP

PA defers to Federal OSHA Standards: 1910 Subpart – PPE that include 1910.132-1910.138 (General requirements, eye and face, respiratory, head, foot, electrical, hand). https://www.osha.gov/sites/default/files/enforcement/directives/CPL_02-01-050.pdf

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook, p. 41-42

MATERIALS NEEDED

Teacher Presentation: Lab setting

Content:

MATERIALS

- Duct tape
- MSDS sheets
- Safety equipment referenced p. 41 (*Energy Conservation Handbook)*

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Safety

90 MINUTES

KEY TERMS

Eye protection
Breathing equipment
Gloves
Hard hat
Coverall
Hood
Booties
Knee pads
Hearing protection

IMPLEMENTATION (LESSON PLAN)

ENGAGE

- Ask *What experiences have you had in using PPE?* Share personal example. Note how experiences comply or not to standards. Perhaps start with COVID mask.

EXPLORE

1. Explain that all labs and tasks explain which PPE are required and that proper use is required to continue.
2. Follow directions on p. 42 of the *Energy Conservation Handbook*, explaining the equipment and give examples of when it is used.
3. Demonstrate to students how to properly wear PPE.
4. Students retrieve individually provided PPE equipment and show the instructor how to properly wear it. If a large number of students, have students pair having one demonstrate, the other watch. The watcher may ask questions only after the demonstrator has finished with the task. Instructor then asks pairs to switch once feedback has been provided.

EXPLAIN

1. Play this OSHA PPE game with two teams. https://servicehospitality.com/wp-content/uploads/2017/06/3.-Win-Lose-or-Draw-PPE-Activity.pdf
2. Debrief with the whole group once all students have finished.
    a. What components were easiest to secure properly?
    b. What was the hardest and why?
    c. What will you be sure to try next time?

EXTEND/EVALUATE

- Discuss maintenance of PPE, disposal of consumables, and storage of non-consumables

RESOURCES/LINKS

WXTV Montana 12:30 video on PPE and Respirators. Can be used selectively. Gives a basic overview but only show some and a time and discuss and relate to activities.

http://wxtvonline.org/2010/09/respirators-ppe/

OR

https://www.youtube.com/watch?v=QOEjxFqT7QM

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Safety

90 MINUTES

LESSON

Introduction to Energy Conservation & Efficiency

BIG IDEA(S)

Energy conservation is the decision and practice of using less energy. Energy efficiency is using technology that uses less energy to perform the same function.

OBJECTIVES

Students will:

- List at least five ways to conserve energy in general (human body, school community, home, etc).
- Identify major sources of energy use in the home.
- Describe three practices that could be implemented in their own homes to conserve energy and save money.
- Differentiate between energy conservation and energy efficiency
- Create an argument that demonstrates why conserving energy is good for the health of the planet.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency and Conservation

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
104	Describe sources and uses of energy
810	Use energy efficiency industry vocabulary

KEY TERMS

Energy Conservation - the decision and practice of using less energy

Energy Efficiency - using technology that uses less energy to perform the same function

OVERVIEW

Everyone uses energy. Typical energy usages include, transportation, cooking, heating and cooling, lighting, entertainment, and more. Energy conservation is the decision and practice of using less energy. Two reasons people may conserve energy is to:

1) reduce the amount of money spent on their energy bill and

2) to reduce the demand on the earth's natural resources. Energy conservation involves changing behaviors and habits.

Energy efficiency is using technology that uses less energy to perform the same function. (See Energy Efficiency statement in the References.)

STANDARDS

PA/SDP

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws.

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, p. 7-11

MATERIALS NEEDED

Content: Year 1 Lesson 2 Worksheet

Technology: Device with internet to review websites

IMPLEMENTATION (LESSON PLAN)

ENGAGE

Using the think-pair-share method ask the class to brainstorm examples of energy uses in our society. Teacher can list student responses on the board or a shared Google doc. Responses might include: transportation, cooking, human activities such as exercise, heating, cooling, lighting.

EXPLORE

1. Part 1 - Using the list of examples of energy usage created in the engage section above, ask pairs of students to identify how you might cut down on the energy used for each of the items listed above.
2. Part 2 – Using the Energy Star website (https://www.energystar.gov/products), have pairs of students pick a product from the list and research the item. Students should gather the following information:
    - Product description
    - Description of energy saving features
    - Costs per year to use the product

EXPLAIN

Review students' results from the questions as a whole class. Students can report out on the product that they researched.

EXTEND/EVALUATE

As an exit ticket, have students complete the following task in 2-3 sentences, "Create an argument that demonstrates why conserving energy is good for the health of the planet."

HOMEWORK

1. Identify what type of energy your home uses for heating (electricity, natural gas, oil).
2. Identify what type of energy your home's hot water heater uses: electricity or natural gas.
3. Identify one or more energy star products in your home.
4. Identify at 2 possible ways that your home could be more energy efficient.

RESOURCES/LINKS

Constellation Energy Company
https://www.constellation.com/energy-101/what-is-energy-conservation.html

Energy Star products
https://www.energystar.gov/products

U.S. Energy Information Administration
https://www.eia.gov/energyexplained/use-of-energy/efficiency-and-conservation.php

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency and Conservation

90 MINUTES

FURTHER BACKGROUND

Energy Efficiency: Why both Solar PV Installation and Weatherization Must Go Together

Energy Efficiency refers to the renovations and retrofits we do to a building to reduce the energy usage and the cost to the home or property owner. For example, incandescent light bulbs are cheaper than LED light bulbs, but LEDs are 90% more energy efficient and LED's last longer. The amount you will save on electricity by using LED's will more than make up the cost difference.

In the energy efficiency portion of the Solar PV Installer program, we demonstrate to the student how energy is used in a building – conditioning of space (heating and cooling), baseload (electrical appliances, microwaves, refrigerators, space heaters etc.), heating of water, other (TV's, computers, stereo equipment etc.). By using a kill-o-watt meter students can determine the amount of electricity that is being used. We then determine the amount of time each appliance is used over the course of a year. We then take the amount of electricity that is being used over the course of a year and multiply it by the PECO rate per kilowatt hour and we will see the cost per year to use that item.

Students will learn to use a Blower Door which is an instrument that depressurizes a house to determine where there is air leakage. Air leakage will cause your HVAC system to work overtime to compensate for the leakage. By insulating and air sealing we can make your HVAC system operate more efficiently and reducing the cost you pay for energy usage.

The goal is to demonstrate how energy efficiency effects the installation of a Solar PV System. The size of the system and the design is determined by the amount of electricity used. If the appliances and the condition of the building is inefficient you will be paying more for a solar installation than if the building is energy efficient. If someone is thinking of installing a solar PV system on their house, the basic rule is to first determine the energy efficiency of the building and the appliances.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency and Conservation

90 MINUTES

LESSON

Introduction to the Weatherization Process

BIG IDEA(S)

Weatherization is the process of reducing energy consumption and increasing comfort in buildings by improving energy efficiency.

OBJECTIVES

Students will:

- List a minimum of five weatherization measures
- Define and describe weatherization
- Define and describe "house as a system"

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

102 Describe how energy is fundamental to our everyday lives

104 Describe sources and uses of energy

809 Use industry vocabulary

OVERVIEW

Weatherization is a process that requires analysis of buildings in order to decide the best ways to safely provide energy saving measures, requiring familiarity with older and existing building technologies that need to be fixed to be healthier, more comfortable and energy efficient. This is a money saver, especially for lower income households. For buildings that will use solar power for energy, it means using the solar energy efficiently. The guiding principle in all of the weatherization curriculum is that a house is a system where any part that is changed affects the rest of the house.

STANDARDS

PA/SDP

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws.

KEY TERMS

air sealing
building science
house as a system
insulation
retrofit
stack effect
weatherization

DEFINITIONS OF KEY TERMS

Air sealing: the process of making a home more airtight by sealing up small or big gaps, cracks, and holes.

Building science: using modern technology to study construction, maintenance, safety and durability

House as a system: components of a building are connected to each other and form a single system; conditions in one part of the home affect conditions in another part of the home.

Insulation: helps keep warm and cool air from leaving and entering the home by preventing heat loss

Retrofit: weatherization of existing older homes (as opposed to new construction)

Stack effect: warm air rises and creates a positive pressure zone in the top part of the home and a negative pressure zone in the lower part.

DEFINITIONS OF KEY TERMS (CONTINUED)

Weatherization: the process of reducing energy consumption and increasing energy efficiency of the building

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, pp. 7-12

MATERIALS NEEDED

Content: Year 1 Lesson 3 Worksheet

Technology: Device with internet to watch YouTube video

IMPLEMENTATION (LESSON PLAN)

ENGAGE

- Using think-pair-share method ask the class to reflect on the following question: *What does weatherization mean?* Teacher can list student responses on the board or a shared Google doc. Responses might include: protecting something from weather, keeping the weather out of a building, making repairs to fix drafts, etc.

EXPLORE

- At the front of the classroom display a collection of air sealing and insulation products including various types of spray foam, caulks, weather stripping, insulation and foam board.
- While using proper PPE, ask students to come up and observe/inspect the items. In their notebooks ask students to record each item and write a one-sentence description of each item's purpose. Optional: have students classify the items as either air sealing or insulation.

EXPLAIN

- Working in pairs have students complete Year 1 Lesson 2 Worksheet, completing the questions and diagram. As a whole class have students report out on their answers.

EXTEND/EVALUATE

- Introduce the concept of "House as a System" by showing the video "Tale of Weatherization at Grandma's House": https://homeenergysaver.ning.com/video/a-tale-of-weatherization-at-grandma-s-house

HOMEWORK

Identify one area of your home that could benefit from a weatherization measure. In your notebook write a 1-2 sentence description of the weatherization measure and explain why that is the best solution.

RESOURCES/LINKS

A Tale of Weatherization at Grandma's House video

https://homeenergysaver.ning.com/video/a-tale-of-weatherization-at-grandma-s-house

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

History of Weatherization and the Weatherization Assistance Program

BIG IDEA(S)

The US government has encouraged and supported weatherization since the 1970s.

OBJECTIVES

Students will:

- Define and describe the history of weatherization in the US.
- List a minimum of five weatherization priorities identified by the US government.
- Define and describe the current Weatherization Assistance Program (WAP).
- Explain the steps of the WAP process.
- Compare and contrast weatherization of new construction and retrofitting old homes.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
104	Describe sources and uses of energy
809	Use industry vocabulary
801	Identify the principles of building science
809	Apply math skills to weatherization

KEY TERMS

air sealing
building science
house as a system
Insulation
retrofit
weatherization

OVERVIEW

The US government has encouraged and supported weatherization since the 1970s. Current programs attempt to use the most cost-effective strategies to create the largest reductions of energy. These strategies were identified and a priority list was created. As a result, home owners save money on utility bills. Additionally, the strategies can create a more comfortable home. Newly constructed homes usually have these strategies/ measures built in during the construction process. Older homes built prior to the early 1970s must be retrofitted with weatherization measures.

STANDARDS

PA/SDP

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws.

DEFINITIONS OF KEY TERMS

Air sealing: the process of making a home more airtight by sealing up small or big gaps, cracks, and holes.

Building science: using modern technology to study construction, maintenance, safety and durability

House as a system: components of a building are connected to each other and form a single system; conditions in one part of the home affect conditions in another part of the home.

DEFINITIONS OF KEY TERMS (CONTINUED)

Insulation: helps keep warm and cool air from leaving and entering the home by preventing heat loss

Retrofit: weatherization of existing older homes (as opposed to new construction)

Weatherization: the process of reducing energy consumption and increasing energy efficiency of the building

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, pp. 7-12

MATERIALS NEEDED

Content: Year 1 Lesson 4 Worksheet

Technology: Device with internet to watch YouTube video

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. Show the "Weatherization Assistance Program: A Program that Works" video: https://youtu.be/6VaF6GO0W-8 (10 min)
2. Ask students to answer Year 1 Lesson 4 worksheet questions and record 3 facts while watching the video.
3. At the end of the video ask students to share their facts about WAP.

EXPLORE

1. In pairs have students use their laptops/tablets to look up the following websites about the WAP:
   - LIHEAP Handbook Weatherization Assistance Program: http://services.dpw.state.pa.us/oimpolicymanuals/liheap/698_Weatherization/698.2_Types_of_Weatherization_Work_Performed.htm
   - South Central Community Action Programs: Weatherization: https://www.sccap.org/weatherization
   - Philadelphia Housing Development Corporation: http://www.huntingparknac.org/files/weatherization-assistance.pdf
2. Ask students to make a list of all of the services covered under the WAP.
3. Have students read pages 9-13 in the *Energy Conservation Training Handbook*.
4. Once students are familiar with the WAP history and services, have students create a 1-min informational video that could be shown to potential WAP customers. Video must contain the following elements:
   - What is weatherization?
   - What does weatherization do?
   - Who pays for it?
   - Who qualifies for weatherization?

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

EXPLAIN

- Students share their videos with the rest of the class.

EXTEND/EVALUATE

- Ask a family member if they have heard about the WAP. Share your informational video with them.

HOMEWORK

Watch the Energy Coordinating Agency's web site's video about WAP in Philadelphia: https://www.ecasavesenergy.org/who-we-are

RESOURCES/LINKS

Energy Coordinating Agency (ECA):

https://www.ecasavesenergy.org

How to Apply for the Weatherization Assistance Program:

https://www.energy.gov/eere/wap/how-apply-weatherization-assistance

LIHEAP Handbook Weatherization Assistance Program:

http://services.dpw.state.pa.us/oimpolicymanuals/liheap/698_Weatherization/698.2_Types_of_Weatherization_Work_Performed.htm

South Central Community Action Programs: Weatherization:

https://www.sccap.org/weatherization

Update from the Department of Energy's Weatherization Assistance Program webinar February 2021:

https://youtu.be/9aSVT_gkS6Q

Weatherization Assistance Program: A Program that Works:

https://youtu.be/6VaF6GO0W-8

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

The Roles and Duties of a Weatherization Retrofit installer/ Technician

BIG IDEA(S)

Auditors and weatherization technicians need to understand the cost-effectiveness of such work in saving energy and providing explanations to clients. The role of the installer is to successfully fulfill the work site's work scope (work order) while keeping in mind health and safety concerns.

OBJECTIVES

Students will:

- Recognize that building science guides the selection of measures installed with program dollars
- Interpret work orders
- Identify potential health and safety concerns related to a work order's installation
- Summarize the principles of cost-effectiveness and the savings-to-investment ratio (SIR)

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
104	Describe sources and uses of energy
801	Identify the principles of building science
810	Use energy efficiency industry vocabulary

KEY TERMS

Work Scope: full list of work to be performed and materials to be installed; also known as a work order.

OVERVIEW

Auditors and weatherization technicians need to understand the cost-effectiveness of such work in saving energy and providing explanations to clients. The role of the installer is to successfully fulfill the work site's work scope (work order) while keeping in mind health and safety concerns. Installers must 1) have knowledge of how to apply weatherization measures, and 2) have the physical ability to apply the measures on the job. Installers must also keep safety a top priority for themselves and the occupants of the home.

STANDARDS

PA/SDP

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws.

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, pp. 15-17; 69-71

MATERIALS NEEDED

Content: Sample Work Scope

Technology: Device with internet to watch YouTube video

IMPLEMENTATION (LESSON PLAN)

ENGAGE

- Ask the class what they think the role of a Weatherization Installer to be. Write ideas on the board. Complete the Weatherization Tech Job checklist together (Year 1 Lesson 4 worksheet).
- Use the video presentation and discussion to teach students about the work of a technician involved in the Weatherization Assistance Program (WAP). https://www.youtube.com/watch?v=qGOwR2jKDpA. Ask students to pay attention to what technicians are doing in the video to get a sense of the work and how they are related to the main goals of the main goals of weatherization.

EXPLORE

1. Provide each student with a copy of a sample work order. Ask students to explain the various sections.
2. Have groups of 2-3 students work together to analyze the work order and develop a plan of action for the work. Students should include:
    a. A list of all tools needed
    b. A list of weatherization materials needed and their amounts
    c. A list of safety considerations that will need to be enacted

EXPLAIN

- Have student teams present their action plan for their work order. As a whole class have point out the strengths and weaknesses of each team's plan.

EXTEND/EVALUATE

- As individuals or in pairs, have student construct a classified ad/job description for a Weatherization Retrofit Installer Technician for their future business.

HOMEWORK

Using Indeed.com conduct a job search and find 2 current job openings for a weatherization installer.

RESOURCES/LINKS

The Weatherization Assistance Program: 40 Years of Improving Homes and Lives

https://youtu.be/qGOwR2jKDpA

Wisconsin Weatherization Assistance Program Manual 2021:

http://homeenergyplus.wi.gov/docview.asp?docid=28958&locid=25

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

SAMPLE CLASSIFIED ADVERTISEMENT (FOR INSTRUCTOR USE)

FULL JOB DESCRIPTION

Home Energy and Comfort, Pennsylvania's only BPI GoldStar Contractor focused on whole home performance, is looking for Insulation and Weatherization Technicians and Installers to support the installation of home performance recommendations in primarily residential settings. The ideal candidate will be punctual, hard working, and good at communicating with both staff and customers. We are looking for motivated individuals with a desire to learn, secure long-term employment, and help people and the planet.

Either BPI credentials or experience in the home performance industry are preferred. We will certainly consider candidates that do not, as we can train anyone. Please send a resume and a list of at least 2 professional references. Message with any questions. We are conducting interviews on a rolling basis until the positions are filled.

Hourly wage is dependent on experience, training, and certifications and shall be no lower than $15 an hour. Technicians and installers typically earn $15 - $20 an hour. A typical work week is 32-40 hrs with overtime available some weeks. Worker's Compensation, paid holidays, and earned vacation time provided. Annual bonuses and pay raises provided based on performance.

Work Experience Requirements:

- Experience in the weatherization and insulation trades preferred

Education/Certification/License Requirements:

- High school diploma or GED preferred
- Associate's or Bachelor's degree preferred
- BPI, HERS, and/or LEED credentials strongly preferred
- Must have valid PA driver's license and safe, reliable transportation

Computer Skill/Training Requirements:

- Basic knowledge of and experience with computers, tablets, smart phones
- Building science, carpentry, and/or construction training/experience preferred

Primary Responsibilities:

- Review work scopes and prep/plan for installations (10%)
- Travel to and from job sites using personal transportation and/or company vehicle (10%)
- Installing home performance recommendations including insulation (fiberglass, cellulose, spray foam, rigid board, etc.), air sealing, weather stripping, as well as associated prep and clean up of project sites (80%)

Environmental Conditions:

- Work areas are typically residential attics, basements, and crawl spaces.
- We will provide all safety equipment for employee to work safely and effectively.

Physical Requirements:

- Must be able to lift 50 lbs. regularly and occasionally 75+ lbs.
- Must be able to work safely and effectively in different conditions and spaces
- Must be able to smile and have a good time even on a tough day
- Good sense of humor highly recommended and preferred

Please send a professional resume and at least 2 professional references.

Job Type: Full-time

Salary: $15.00 to $20.00 /hour

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

SAMPLE CLASSIFIED ADVERTISEMENT - CONTINUED

Experience:

- Building trades: 1 year (Preferred)

License:

- PA driver's license (Required)

Work Location:

- Multiple locations

Typical start time:

- 7AM

Typical end time:

- 3PM

Company's website:

- www.EnergyAndComfort.com

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

WAP Priority List of Energy Saving Measures & Savings to Investment Ratio

BIG IDEA(S)

Some energy saving measures are used more frequently because they more cost-efficient.

OBJECTIVES

Students will:

- Identify top priority list measures
- Explain why some measures are higher on the list than others
- Identify top health and safety issues for workers and building occupants
- Explain the Savings to Investment Ratio

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
106	Describe the impact of energy systems (economic, health, environmental)
801	Identify the principles of building science
810	Use energy efficiency industry vocabulary

OVERVIEW

An energy auditor creates a list of measures to be completed in the home. The sequence of measures is based upon a state list. The list is created base of maximizing cost-effectiveness. The list must be performed in order; otherwise funding could be at risk. Measures higher on the list must be performed first. The order of measures is based on a variety of factors such as overall condition of the house, repairs needed, and weatherization needs. The Savings to Investment Ratio helps to determine the cost of a measure as it relates to the long term savings from investment. Health and safety of workers and occupants is a top priority. If a building is unsafe the work cannot be performed until the issues are resolved.

KEY TERMS

Work Scope: full list of work to be performed and materials to be installed; also known as a work order.

STANDARDS

PA/SDP

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws.

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, pp. pp. 18-19, 24-25

MATERIALS NEEDED

Content: PA Priority List

Technology: Device with internet to watch YouTube video

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. Watch the video, *The Weatherization Assistance Program: A Client's Story*: https://youtu.be/IDgaL7Z3DHo
2. Ask students if they can relate to Carlos' wanting to help people like the woman in the story.

EXPLORE

1. In advance put each measure from the priority list on page 18 on a separate index card or print on a slip of paper. Create enough materials for students to work in groups of 2-3 students.
2. Provide each group with a set of the priority measures.
3. Have groups sort and rank the measures in a list of highest level of cost-effectiveness to lowest level.

EXPLAIN

- Have student teams present their top five measures in order of cost-effectiveness and explain their rationale.

EXTEND/EVALUATE

- Have student groups look up the cost of a minimum of five different materials from the priority list in order to see the price differences. Include in the list:
  - Caulk
  - Front door
  - Refrigerator
  - Insulation
  - Spray foam
- Have students calculate the Savings to Investment Ratio for a minimum of three items. (p. 25) (see sample at end of lesson plan)

HOMEWORK

With your family, use the questionnaire a WAP Auditor would use for a homeowner. How is this information helpful for someone who is auditing the house?

https://hcr.ny.gov/system/files/documents/2018/10/wap11hhquest.pdf

RESOURCES/LINKS

PA Weatherization Field Guide

https://www.paweatherization.org/vertical/sites/%7BF27E296C-7668-49FF-9408-DF453C70C62E%7D/uploads/%7BCA71D0C1-C3CE-4B1A-9858-B75BD3F5AF92%7D.PDF

The Weatherization Assistance Program: A Client's Story

https://youtu.be/IDgaL7Z3DHo

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

SIMPLE SAVINGS TO INVESTMENT RATIO (SIR) COMPARISON

ATTIC INSULATION VS. REPLACEMENT WINDOW

Actual SIR calculations supported by NEAT, MHEA, and other approved audit tools account for the Present Value (PV) of money and fuel escalation rates over the lifetime of the measures to arrive at more accurate savings numbers. For the purposes of this exercise, the simple SIR calculations outlined here are adequate.

Use these sample numbers or plug actual numbers based on local audits, installation costs and utility prices to discuss SIR and how it supports measure selection within the WAP.

Change the assumptions and have students complete the calculations.

Attic Insulation

Assumptions

Savings/yr: $100

Lifetime: 25 years

Investment: $400

SIR = Lifetime Savings/Investment

SIR = 25 x 100/400

SIR = 6.25

Replacement Window

Assumptions

Savings/yr: $5/window

Lifetime: 25 years

Investment: $200/window

SIR = Lifetime Savings/Investment

SIR = 25 x 5/200

SIR = .62

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Typical Weatherization Measures

BIG IDEA(S)

Weatherization measures can be classified as old school or modern. Measures address building shell, insulation, mechanical systems, or baseload of a home.

OBJECTIVES

Students will:

- Compare and contrast old school vs modern weatherization measures
- Explain why some measures are more cost-effective than others

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
106	Describe the impact of energy systems (economic, health, environmental)
801	Identify the principles of building science
810	Use energy efficiency industry vocabulary

OVERVIEW

Weatherization measures can be classified as old school or modern. Measures address building shell, insulation, mechanical systems, or baseload of a home. Modern measures are grounded in scientific research and are often more of a priority. Modern measures also look at the whole house and how its components are related; the house as a system view. Many old school weatherization programs focused on replacing doors and windows. We now know that this is one of the least cost-effective measures.

KEY TERMS

Modern Weatherization Measures: based on recent lessons in building science

Old School Weatherization Measures: while still done, are not as cost effective

Baseload: how much energy is used before weatherization

STANDARDS

PA/SDP

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation.

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, pp. 19-22

MATERIALS NEEDED

Technology: Device with internet to watch YouTube video

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. 80s Gaming Analysis - ask students to compare and contrast current video systems such as Playstation or xBox with the Atari 2600. How has technology changed these products? What are some of the differences in "old school" and modern tech?
2. Ask students to brainstorm a list of old school weatherization techniques. If students have difficulty recalling old school weatherization products, share the images from the Old School Measures worksheet.

EXPLORE

1. In advance set up as many measures from the list as possible (blower door, a variety of insulation types, led lighting, CO monitor, heater filters, air sealing materials, etc.). Include a mix of old school and new school measures. Allow students to handle materials and equipment (with appropriate safety measures in mind).
2. In small groups have students classify measures as old school vs new school.
3. Have groups sort classify the measures into one of the four areas in the diagram below.

MECHANICAL MEASURES

- Clean, tune, repair, or replace heating and/or cooling systems.
- Install duct and heating pipe insulation.
- Install programmable thermostats and other HVAC controls.
- Repair/replace water heaters.
- Install water heater tank insulation.
- Insulate water heating pipes.
- Install solar water heating systems.
- Install waste heat recovery devices.

HEALTH & SAFETY MEASURES

- Complete combustion appliance safety testing.
- Repair/replace vent systems to ensure combustion gas draft safely outside.
- Install mechanical ventilation to ensure adequate indoor air quality.
- Assess fire hazards. Install smoke and carbon monoxide alarms when needed.
- Evaluate mold/moisture hazards.
- Perform incidental safety repairs when needed.

BUILDING SHELL MEASURES

- Install wall, floor, ceiling, attic, and/or foundation insulation.
- Complete Blower Door Testing.
- Perform air sealing.
- Repair/replace primary windows/doors.
- Install storm windows/doors.
- Install window film/solar screens/window louvers and awnings.
- Repair minor roof and wall leaks prior to attic or wall insulation.

ELECTRIC BASELOAD MEASURES

- Install motor controls.
- Install efficient light sources.
- Replace refrigerators and freezers with energy efficient models.

EXPLAIN

- Have each student team present one of the measures and describe to the class why it is old school or modern and the type of energy efficiency it may provide.

EXTEND/EVALUATE

- Have student groups look up the differences between incandescent, compact fluorescent, and led bulbs. Using the Year 1 Lesson 6 worksheet have students describe the amount of energy each bulb consumes.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

Typical Weatherization Measures

HOMEWORK

Ask students to take an inventory of the the "old school" measures in their own home.

RESOURCES/LINKS

PA Weatherization Field Guide

https://www.paweatherization.org/vertical/sites/%7BF27E296C-7668-49FF-9408-DF453C70C62E%7D/uploads/%7BCA71D0C1-C3CE-4B1A-9858-B75BD3F5AF92%7D.PDF

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Deferral of Weatherization Measures

BIG IDEA(S)

Weatherization may sometimes need to be postponed.

OBJECTIVES

Students will:

- Identify reasons for deferral of weatherization
- Describe how impediments may be rehabilitated to allow for weatherization to proceed

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
106	Describe the impact of energy systems (economic, health, environmental)
801	Identify the principles of building science
810	Use energy efficiency industry vocabulary

OVERVIEW

Weatherization may sometimes need to be postponed, often due to a safety concern. Sometimes the decision to defer can be optional, but other times deferral is mandatory. Optional deferrals may include unsanitary conditions, threatening animals, or uncooperative clients. Mandatory deferrals include vacant buildings, severe moisture problems, structural issues, and the presence of lead-based paint. Weatherization cannot take place until these issues are resolved.

STANDARDS

PA/SDP

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation.

INSTRUCTIONAL

TEXT/REFERENCES

Training Handbook, p. 23

MATERIALS NEEDED

Technology: Device with internet to watch YouTube video

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

KEY TERMS

Modern Weatherization Measures: based on recent lessons in building science

Old School Weatherization Measures: while still done, are not as cost effective

IMPLEMENTATION (LESSON PLAN)

ENGAGE

- Ask students to explain what might prevent weatherization procedures to take place. Sometimes these are decided by the weatherization provider. *"What would get in the way of doing work in a home?"* List student responses on board.

EXPLORE

- Review p. 23 in the Handbook that provides specific reasons why weatherization can not go forward.
- Assign one optional and one mandatory deferral reason from the list on p. 23 to each pair of students. Have student pairs discuss each problem. Have students role play the scenario and determine the best way to handle each situation in a professional manner. Have each student team present to the whole class one (or both if time allows) of the assigned deferral issues. One student can be the tech and the other student can take on the role of the client.

EXPLAIN

- Complete the Year 1 Lesson 7 worksheet.

EXTEND/EVALUATE

- Have students practice writing a deferral letter to the client explaining the next steps in resolving the problem and rescheduling weatherization.

HOMEWORK

Review the sample deferral checklist.

RESOURCES/LINKS

DCED HOME Program: Weatherization Deferral

https://dced.pa.gov/download/home-program-appendix-3-weatherization-deferral-pilot-initiative-2017/?wpdmdl=86362&ind=0

PA Weatherization Field Guide

https://www.paweatherization.org/vertical/sites/%7BF27E296C-7668-49FF-9408-DF453C70C62E%7D/uploads/%7BCA71D0C1-C3CE-4B1A-9858-B75BD3F5AF92%7D.PDF

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Hand and Power Tools

BIG IDEA(S)

Tools are a critical part of the weatherization process.

OBJECTIVES

Students will:

- Identify solar technology/ weatherization tools and describe examples of their use
- Describe ways that a retrofit installer maintains tools and organizes them for job requirements and easy retrieval
- Describe tool safety for tools and tasks
- Read manufacturer's specification for a specific tool and understand directions

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Hand and Power Tools

90 MINUTES

TASK LIST SUBCATEGORY

311 Recognize, identify and safely use hand tools and power tools

415 Demonstrate knowledge of manufacturer specifications

420 Demonstrate knowledge and use of time management strategies

810 Use energy efficiency industry vocabulary

811 Prepare and maintain tools and equipment used for energy auditing and weatherization tasks

KEY TERMS

Maintaining tools
Manufacturer's Specifications

See pg. 55 of reference text for complete list.

OVERVIEW

The purpose of this Lab is to introduce students to the tools that they will be using throughout the program. The instructor will assemble the tools and tasks to demonstrate, describe their use in weatherization and construction, and demonstrate how to use them safely. Students need to understand how keeping tools organized, ready to use, and selected for each job saves time and bother. The importance of reading the directions from manufacturers is also reviewed.

STANDARDS

PA/SDP

CC.3.5.9-10.C. Reading (Specific Anchor: Key Ideas and Details). Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. Pp.55-63

MATERIALS NEEDED

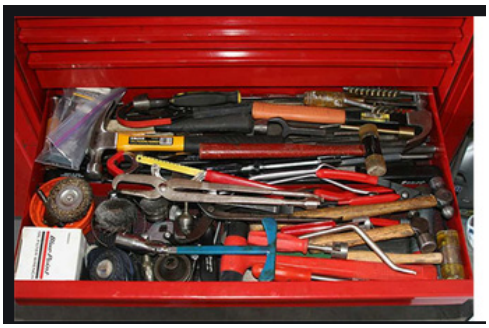
Teacher Presentation: Assemble all tools that are to be demonstrated along with props and materials needed

Content: Year 1 Lesson 9 worksheet

IMPLEMENTATION (LESSON PLAN)

1. Organization of Tools

   In which drawer will you find the tool you need fastest?



   a. In the Shop or Truck: "Every tool in its place." Tools are often shared so be sure there is enough for everyone, and that they go back where everyone knows to find them.

   b. On the Job: Having tools ready for specific jobs in the order of need is a great idea. On p. 157, for this air sealing job of non-IC recessed light fixtures you would have ready the list of Tools, Consumables, and Safety Equipment ahead of time. Think about how they will be carried, loaded and unloaded, cleaned up, and returned. This is all part of the job.

2. Manufacturer's Specifications: It is very important to understand the technical aspects of a tool before using it. This is especially important for power tools which can be dangerous if not used properly. There are directions for things like changing blades and bits, safe operation, and limitations for the tool. Use the Table of Contents below to decide **what section** you would need to read to answer the questions about this circular saw:

   https://images.homedepot-static.com/catalog/pdfImages/b2/b236330b-101b-4751-a981-9c45537f3afa.pdf Full manual here for this circular saw to check the instructions.

TABLE OF CONTENTS

   a. What PPE should you use?

   b. When should the saw be disconnected from electricity?

   c. You suspect that the blade is not sharp and you need to change it?

   d. The saw stops working after using is correctly after 3 months.

   e. You are going to cut a ½ " plywood board. How far down should the blade be?

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Hand and Power Tools

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

1. Demonstrating the Tools (Approx. 45 minutes): The instructor should review demonstration of the procedures before-hand, setting sample jobs where warranted to save time. If any hands-on practice is planned, this lesson will take longer. Make a checklist for smoother sailing.
    a. Hand Tools
        i. Screw drivers are mostly flat or Phillips. There are other kinds and different sizes and lengths for getting into odd spots. If time, review when they come in handy. Also demo using a drill for screws with different bits.

        ii. Tool Belt. If you assemble a tool belt, you might want to put in tools for a specific job like making a drywall repair, or sealing an opening around a pipe.
    b. Power Tools: to consider time, demo just one of the saws but explain how the others work.

HOMEWORK

Match the Tool to Its Use (Year 1 Lesson 9 Worksheet)

RESOURCES/LINKS

Straight Cuts with a Circular Saw

https://www.youtube.com/watch?v=99vUjwFIZuo

How to Use a Circular Saw

www.lowes.com/n/how-to/how-to-use-a-circular-saw

Miter Saw (7:52)

https://www.youtube.com/watch?v=7fjHvYy5lkg

Portable Band Saw

https://www.youtube.com/watch?v=iWXSkrhDMHo

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Hand and Power Tools

90 MINUTES

LESSON

House as a System

BIG IDEA(S)

A system is an organized group of related objects or components; a house is a single system of interrelated parts.

OBJECTIVES

Students will:

- Apply concepts of House as a System to a variety of scenarios
- Explain the interrelatedness of the components of the house as a system

TASK LIST SUBCATEGORY

802 Describe the interconnection of systems

106 Describe the impact of energy systems (social, economic, health, and environmental)

OVERVIEW

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. A house is a single system of connected parts. Simple systems can work in predictable ways; dynamic systems exhibit more complex and unpredictable behaviors.

STANDARDS

PA/SDP

3.1.12.A8. Change and Constancy: Describe and interpret dynamic changes in stable systems

3.2.12.A5. Change and Constancy: Predict the shift in equilibrium when a system is subjected to a stress

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 89 – 92

MATERIALS NEEDED

Content: Videos linked below

Technology: Device with internet to watch YouTube video

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

KEY TERMS

equilibrium
feedback loop
system
systems thinking

IMPLEMENTATION (LESSON PLAN)

PART I – HOUSE AS A SYSTEM COMPONENTS

ENGAGE

- Using think-pair-share method ask the class to brain storm examples of systems. Teacher can list all of the different systems on the board. Responses might include: solar system, healthcare system, human body systems, computer system, software/ operating system, weather systems, natural social system (beehive), mechanical systems (electrical)
- Show PBS video: https://lsintspl3.wgbh.org/en-us/lesson/syslit-il-pdsystems/3 (2:30)

EXPLORE

- Using the list of examples of systems constructed in the engage section above, ask pairs of students to use the following list of questions to determine whether or not the examples are truly systems.

	Yes	No
1. Are there parts?		
2. Do the parts affect each other?		
3. Does it matter how the parts are arranged?		
4. Does the behavior of the system change if a key part is taken away?		
5. Does the interaction of the parts produce an effect that is different than that of any of the parts on its own?		

EXPLAIN

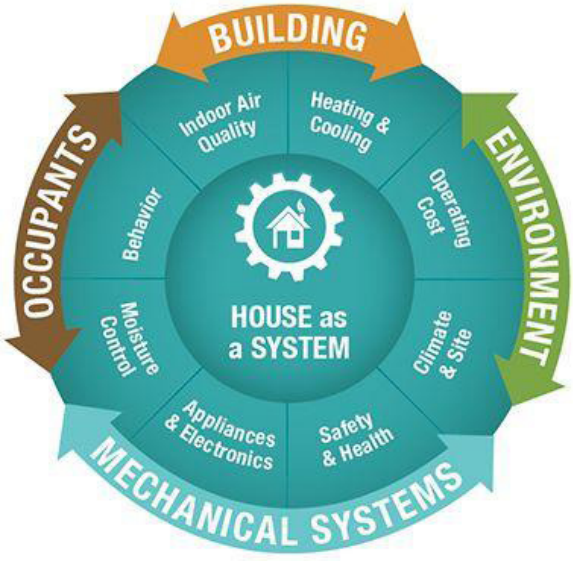
- Review students' results from the questions as a whole class.
- Watch "Clem Marvels at a Mangrove" video (https://lsintspl3.wgbh.org/en-us/lesson/syslit-il-pdsystems/6). Ask students to identify the system and its parts from the video.

EXTEND

- Introduce "House as a System." Ask students if a house is a system. Ask students to apply the five questions from the above Explore section to a house. In pairs have student address each question. Use the *House as a System Worksheet* to answer questions.

EVALUATE

- Teacher may select in advance or ask students to use the diagram below to select two components of the House as a System. Students should then write a one paragraph essay analyzing how the two components are interrelated and ultimately can impact the home's energy efficiency. An alternative assignment could be to turn this into a class game by adding a spinner to the diagram. Students would then spin twice to select their components and verbally analyze the components.



BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

RESOURCES/LINKS

Basic Building Science webinar by The Energy Center of Wisconsin

https://www.youtube.com/watch?v=vCSAjgVUplA

Building Science Basics materials

https://www.energy.gov/eere/wap/downloads/weatherization-installertechnician-fundamentals-20-building-science-basics

Building Science Concepts

https://www.wbdg.org/resources/building-science-concepts

Building Science Concepts: Northern Arizona University

https://mediaspace.nau.edu/media/Building+Science+Concepts/0_9gnqhk0n/69035282

Energy Star Qualified Homes Building Science Introduction

https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/ENERGY_STAR_V3_Building_Science.pdf

Introduction to Building Science powerpoint slides

https://www.tboake.com/2013/172-building_science_13.pdf

National Energy Education Development (NEED) Project: Building Science booklet

https://www.need.org/Files/curriculum/guides/BuildingScience.pdf

PBS Teaching About Systems

https://whyy.pbslearningmedia.org/resource/syslit14-sci-sys-ilpdsystems/teaching-about-systems/#.X2VKLi-ZPVo

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

APPENDIX

SCIENCE STANDARDS

NGSS Crosscutting Concepts

4. Systems and System Models

Show Tips

Below is the progression of the Crosscutting Concept of Systems and System Models, followed by Performance Expectations that make use of this Crosscutting Concept.

4. Systems and System Models			
A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.			
Primary School (K-2)	**Elementary School (3-5)**	**Middle School (6-8)**	**High School (9-12)**
Systems in the natural and designed world have parts that work together. Objects and organisms can be described in terms of their parts.	A system can be described in terms of its components and their interactions. A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.	Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models are limited in that they only represent certain aspects of the system under study.	When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Systems can be designed to do specific tasks.

Source: https://ngss.nsta.org/CrosscuttingConcepts.aspx?id=4

LESSON

Building Science

BIG IDEA(S)

Building science using principles of other science disciplines to understand the house as a system.

OBJECTIVES

Students will:

- Apply concepts of House as a System to a variety of scenarios
- Construct an accurate model of a house system using concept mapping
- Explain the interrelatedness of the components of the house as a system

TASK LIST SUBCATEGORY

801 Identify the principles of building science

802 Describe the interconnection of systems

106 Describe the impact of energy systems (social, economic, health, and environmental)

OVERVIEW

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. A house is a single system of connected parts. Building science is based on the use of scientific principles to understand how the house as a system impacts energy efficiency, air flow, and the overall health, safety, and comfort of the occupants. Building science is an approach to weatherization that uses modern technology to study building construction, maintenance, safety and durability in an effort to increase energy efficiency. (*Energy Conservation Handbook*, p. 89)

STANDARDS

PA/SDP

3.1.12.A8. Change and Constancy: Describe and interpret dynamic changes in stable systems

3.2.12.A5. Change and Constancy: Predict the shift in equilibrium when a system is subjected to a stress

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

KEY TERMS

equilibrium
feedback loop
system
systems thinking

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 89 – 92

MATERIALS NEEDED

Teacher Presentation: U.S. DOE Weatherization/Technician Fundamentals, *House as a System* Powerpoint Presentation: https://www.energy.gov/eere/wap/downloads/weatherization-installertechnician-fundamentals-20-house-system

Content: Videos linked below, worksheets in Appendix

Technology: Access to YouTube

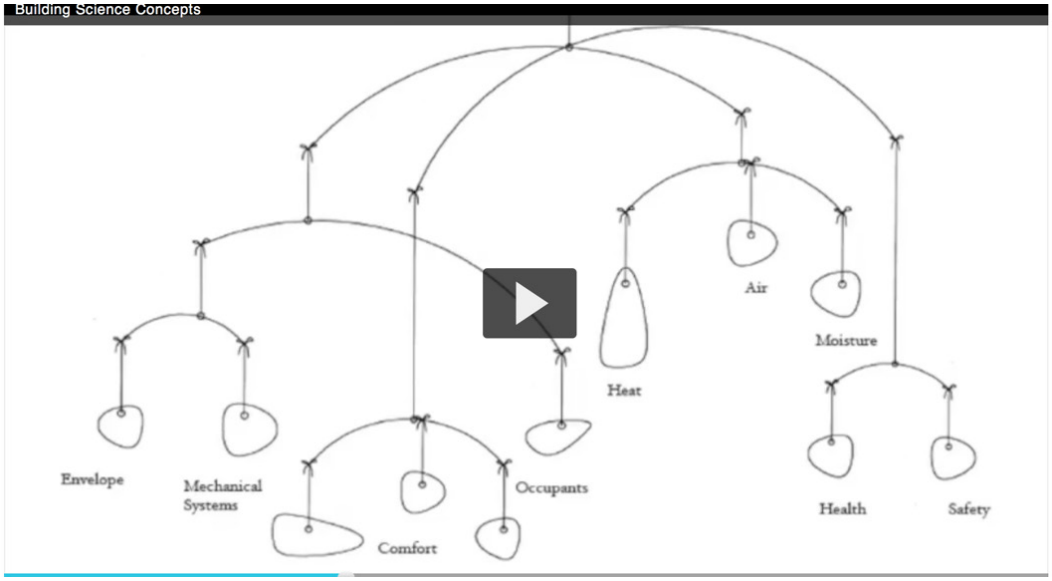
IMPLEMENTATION (LESSON PLAN)

ENGAGE

- Watch the video segment from 3:33 – 9:11 on the interconnectedness of the components of the home: https://mediaspace.nau.edu/media/Building+Science+Concepts/0_9gnqhk0n/69035282

EXPLORE

- Have students create their own concept maps/graphic organizers similar to the mobile shown in the video above and image below. Include the concepts listed below in the circles and on the linking lines describe how each of the components are related to each other.



EXPLAIN/EXTEND

- Ask students to discuss their concept maps. Ask students to draw a cutaway diagram of their own home and label with the above components.

EVALUATE

- Students can take quiz found on pages 169-170 in the *Energy Conservation Training Handbook*.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

RESOURCES/LINKS

Basic Building Science webinar by The Energy Center of Wisconsin

https://www.youtube.com/watch?v=vCSAjgVUplA

Building Science Basics materials

https://www.energy.gov/eere/wap/downloads/weatherization-installertechnician-fundamentals-20-building-science-basics

Building Science Concepts

https://www.wbdg.org/resources/building-science-concepts

Building Science Concepts: Northern Arizona University

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Energy Star Qualified Homes Building Science Introduction

https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/ENERGY_STAR_V3_Building_Science.pdf

Introduction to Building Science powerpoint slides

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National Energy Education Development (NEED) Project: Building Science booklet

https://www.need.org/Files/curriculum/guides/BuildingScience.pdf

PBS Teaching About Systems

https://whyy.pbslearningmedia.org/resource/syslit14-sci-sys-ilpdsystems/teaching-about-systems/#.X2VKLi-ZPVo

U.S. DOE Weatherization/Technician Fundamentals, House as a System, ppt.

https://www.energy.gov/eere/wap/downloads/weatherization-installertechnician-fundamentals-20-house-system

Whole Building Design Guide

https://www.wbdg.org/continuing-education/wbdg-courses/wbdg15

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Health and Safety in the House

BIG IDEA(S)

Air flow and moisture in the home can impact the health and safety of the occupants.

OBJECTIVES

Students will:

- Apply concepts of House as a System to a variety of scenarios
- Explain the interrelatedness of health and safety of the house to the "house as a system" approach

TASK LIST SUBCATEGORY

801 Identify the principles of building science

802 Describe the interconnection of systems

106 Describe the impact of energy systems (social, economic, health, and environmental)

OVERVIEW

A house is a single system of connected parts. Simple systems can work in predictable ways; dynamic systems exhibit more complex and unpredictable behaviors. Building science is based on the use of scientific principles to understand how the house as a system impacts energy efficiency, air flow, and the overall health, safety, and comfort of the occupants. Negative health and safety issues are avoided when approaching the house as a system of interactive parts. However, older buildings may have preexisting conditions and present hazards that workers must recognize and sometimes avoid.

STANDARDS

PA/SDP

3.1.12.A8. Change and Constancy: Describe and interpret dynamic changes in stable systems

3.2.12.A5. Change and Constancy: Predict the shift in equilibrium when a system is subjected to a stress

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

KEY TERMS

equilibrium
feedback loop
system
systems thinking

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 89 – 92

MATERIALS NEEDED

Content: Website linked below

Technology: Internet access

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. Place something in the classroom that has a strong (possibly offensive, but still safe) odor such as a strong-smelling body spray, or perhaps a food item that has a lot of garlic in it; something that will permeate the room.
2. Ask students how they can get rid of the odor. Ask students to identify some of the odors that you might smell in someone's home. Ask how odors in homes are dealt with (bathroom usage, cooking, pets, etc.).

EXPLORE

- Have students discuss in small groups three scenarios and come up with solutions to remove the odor/pollutant from the home.

  Scenario #1 – Aida's grandmother loves to cook fried plantains. She makes them at least three times per week. She fries them in a large skillet filled with cooking oil. You don't like to visit her because the house always smells like fried food. What can you do to help Aida's grandmother's house smell a little more pleasant without telling her she needs to stop cooking plantains?

  Scenario #2 – The Smith family lives on a very busy street. There are many trucks that use this street. The youngest child in the family was just diagnosed with asthma. What can the family do to their house to improve the air quality inside of the home?

  Scenario #3 – The Ayala family just moved into a new house with brand new carpeting in the bedrooms on the second floor. The carpets have a strong order due to a phenomenon called "off-gassing." Small chemical particles used in making the carpets are being released into the air of the home. What can the family do to improve the ventilation in their home?

EXPLAIN

- Student groups report on the solutions to the scenarios.

EXTEND

1. Ask students to identify and discuss how they have handled odors in their own home.
2. Have students read the following web site (https://fyi.extension.wisc.edu/house/about-the-house/home-health-hazards/) and have students take turns summarizing in their own words each of the hazards addressed on the web site.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

EVALUATE

- Ask students to read the passage below and write a short essay addressing 1) how the health and safety of homes contributes to overall health of the occupants, and 2) how society can do a better job at ensuring lower-income families have access to healthy and safe housing.
- The World Health Organization (WHO) has recognized housing as a fundamental social determinant of health (SDH)1. And WHO's Commission on Social Determinants of Health has stated that access to quality housing is a necessary element in securing social justice and health equity: *"The daily conditions in which people live have a strong influence on health equity. Access to quality housing and shelter and clean water and sanitation are human rights and basic needs for healthy living."*

RESOURCES/LINKS

Basic Building Science webinar by The Energy Center of Wisconsin

https://www.youtube.com/watch?v=vCSAjgVUplA

Building Science Concepts

https://www.wbdg.org/resources/building-science-concepts

Building Science Concepts: Northern Arizona University

https://mediaspace.nau.edu/media/Building+Science+Concepts/0_9gnqhk0n/69035282

Home Health Hazards

https://fyi.extension.wisc.edu/house/about-the-house/home-health-hazards/

Introduction to Building Science powerpoint slides

https://www.tboake.com/2013/172-building_science_13.pdf

National Energy Education Development (NEED) Project: Building Science booklet

https://www.need.org/Files/curriculum/guides/BuildingScience.pdf

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Moisture, Mold, Mildew and Health Problems

BIG IDEA(S)

Air flow and moisture in the home can impact the health and safety of the occupants.

OBJECTIVES

Students will:

- Identify typical sources of moisture in a home
- Explain the role of a vapor barrier

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Health and Safety

90 MINUTES

TASK LIST SUBCATEGORY

801 Identify the principles of building science

802 Describe the interconnection of systems

106 Describe the impact of energy systems (social, economic, health, and environmental)

OVERVIEW

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. A house is a single system of connected parts. Simple systems can work in predictable ways; dynamic systems exhibit more complex and unpredictable behaviors.

KEY TERMS

dew point
evaporation
condensation
water vapor
mildew
vapor barrier

STANDARDS

PA/SDP

3.1.12.A8. Change and Constancy: Describe and interpret dynamic changes in stable systems

3.2.12.A5. Change and Constancy: Predict the shift in equilibrium when a system is subjected to a stress

3.3.10.A5. Water: Explain the processes of the hydrologic cycle.

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 101 – 105

MATERIALS NEEDED

Content: Videos/files linked below, worksheet(s) in Appendix

Technology: Access to YouTube

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. As a teacher demonstration, place two clear glasses of water side-by-side in the front of the room so that they are visible to students. One glass should have several ice cubes (3/4 full of ice). The other glass should have no ice.
2. Ask students to make observations in their notebooks. Allow students to touch the glass if they ask to do so. They should list the difference between the two glasses and notice that only the glass with ice has condensation on the outside.
3. In order to have students understand that the condensation on the outside of the glass with the ice is due to water vapor in the room and not water from inside of the glass, ask students to design an investigation that demonstrates where the condensation is coming from. Teacher may hint to students to cover the glass. Another method would be to add food coloring to the glass. Explain to students that the temperature that the water vapor begins to condensate on surfaces is called the "dew point."

EXPLAIN

- In small groups have students research common sources of water vapor in the home. Students should find on their own the following sources: people, pets, plants, clothes washing and drying, house foundation, showers and bathing, dishwashing, cleaning and cooking. Students should document the following and add more sources as necessary.

Source of Water Vapor	Description of how the vapor is released into the home	Amount
1.		
2.		
3.		

EXTEND/EVALUATE

1. As a whole group, ask students to brainstorm examples of mold. Have students complete a KWL chart.
2. Watch the episode on mold and moisture health: http://wxtvonline.org/2011/01/mold/
3. Have students read the *Mold, Moisture, and Your Home* PDF booklet (https://www.epa.gov/sites/production/files/2016-10/documents/moldguide12.pdf) and answer the worksheet questions.
4. Have students finish the KWL chart, completing the L column.

RESOURCES/LINKS

Classification Guide to Common Mold Types

https://www.moldbacteria.com/mold-types.html

The Effect of Indoor Humidity on Water Vapor Release in Homes

https://web.ornl.gov/sci/buildings/conf-archive/2007%20B10%20papers/071_TenWolde.pdf

Home Health Hazards

https://fyi.extension.wisc.edu/house/about-the-house/home-health-hazards/

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

RESOURCES/LINKS (CONTINUED)

Moisture Problems

https://fyi.extension.wisc.edu/house/about-the-house/moisture-problems/

Mold, Moisture, and Your Home pdf booklet from the EPA

https://www.epa.gov/sites/production/files/2016-10/documents/moldguide12.pdf

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Baseload/Seasonal Load

BIG IDEA(S)

a) Baseload energy usage varies very little throughout the year; seasonal load energy can change drastically based on the time of year. b) Baseload energy usage can be reduced with consumer education.

OBJECTIVES

Students will:

- Distinguish between baseload and seasonal load costs
- Given a set a yearly energy bills accurately calculate baseload and seasonal load costs
- Using technology such as Adobe Spark, YouTube, TikTok, etc., create a consumer education social media campaign highlighting ways to reduce baseload home energy costs with a minimum of three strategies
- Summarize the step for calculating baseload and seasonal load costs

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

120-150 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
104	Describe sources and uses of energy
809	Apply math concepts to weatherization
810	Use industry vocabulary

KEY TERMS

baseload
seasonal conditioning load
phantom/vampire power

OVERVIEW

Baseload energy is the energy that is used in the same amount year-round. This often comes from appliances that are used daily such as refrigerators, lights, and electronics. Baseload is not directly affected by seasonal changes in temperature. An estimate of baseload energy usage can be calculated by analyzing energy bills. Consumer education methods can help the public lower their baseload costs.

STANDARDS

PA/SDP

3.2.12.A9. Formulate and revise explanations and models using logic and evidence.

3.2.12.B2. Explain how energy flowing through an open **system** can be lost.

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.1.12.B7. Interpret results of experimental research to predict new information, propose additional investigable questions, or advance a solution.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies.**

3.4.12.B2. Illustrate how, with the aid of **technology**, various aspects of the environment can be monitored to provide information for decision making.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Training Handbook. pp. 23-24, 96-101, and 115-118

MATERIALS NEEDED

Teacher Presentation: Baseload Measures PowerPoint (optional)

Content: *Utility Bill Analysis* worksheet and sample bills

Technology: Calculator, access to social media creation tools such as Adobe Spark, YouTube, TikTok, a digital video recording device such as a cell phone camera

IMPLEMENTATION (LESSON PLAN)

ENGAGE (10 - 15 MIN)

- Ask students to brainstorm a list of all of the appliances or devices in their homes that are left on regularly. Teacher will create a master list on the board or on an electronic Google doc. Ask students to sort their responses by year-round or only certain times of the year.

EXPLORE (45 - 60 MIN)

1. Have students work in pairs. Provide each team of students with a 12 month set of electric and gas bills and the "Utility Bill Analysis worksheet."
2. Have students complete the table and calculate baseload and seasonal load.

EXPLAIN (10 - 20 MIN)

1. Student teams report back results to whole group, explaining results.
2. Ask students to create a definitions of the terms "baseload" and "seasonal load."

EXTEND (10 - 20 MIN)

1. Revisit the list of items students brainstormed at the beginning of the lesson. Ask students to classify the energy use of each item as either baseload or seasonal.
2. Ask students to think of ways to reduce the baseload costs in their homes

EVALUATE (40-75 MIN)

- Students will create a consumer education social media campaign using technology such as Adobe Spark, YouTube, TikTok, etc., highlighting ways to reduce baseload home energy costs with a minimum of three strategies. Video should be approximately 3 minutes in length. Could be assigned whole or partially as homework.

RESOURCES/LINKS

WAP Baseload Measures lesson and PowerPoint:

https://www.energy.gov/eere/wap/downloads/energy-auditor-single-family-20-base-load-measures

Home Idle Load: Devices Wasting Huge Amounts of Electricity When Not in Active Use

https://www.nrdc.org/sites/default/files/home-idle-load-IP.pdf

Department of Energy Baseload/Seasonal Load PowerPoint

https://www.energy.gov/sites/prod/files/2016/07/f33/8_base_load_measures_v2.0.pptx

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

120-150 MINUTES

LESSON

Energy Conservation Materials and Measurement

BIG IDEA(S)

Modern weatherization measures are cost effective ways to conserve energy.

OBJECTIVES

Students will:

- Compare and contrast "old school" and modern weatherization measures
- Describe at least two weatherization measures for each category: building shell, incidental, mechanical, and electric

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

801 Identify the principles of building science

802 Describe the interconnection of systems

810 Use industry vocabulary

OVERVIEW

Weatherization measures can be classified as "old school" or modern. Modern weatherization measures are grounded in the building science field. Modern measures also tend to be more cost-effective than older traditional methods of weatherization. Modern measures can be categorized as follows: a) building shell and insulation; b) incidental measures; c) mechanical systems measures; and d) electric measures.

KEY TERMS

baseload
building shell
weatherization measures
incidental measures

STANDARDS

PA/SDP

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies.**

3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 19-22

MATERIALS NEEDED

Teacher Presentation: Introduction to Weatherization PowerPoint presentation.

Content: Old School Measures worksheet, Modern Measures worksheet

Technology: Access to YouTube

IMPLEMENTATION (LESSON PLAN)

ENGAGE (15 - 20 MIN)

- 80s Television Commercial Analysis
  a. Ask students to imagine what life was like back in the late 1970s and early 1980s. Select 3-4 vintage television commercials listed below to share with the class.
     - Apple Macintosh 1984 Superbowl commercial: https://youtu.be/2zfqw8nhUwA
     - Commodore 64: https://youtu.be/JpZEjoKwFTM
     - Atari 2600 Game Console: https://youtu.be/7WjyBdLqzdg
     - IBM5100: https://youtu.be/KcUR65bju78
     - Historic tech breakthroughs: https://youtu.be/Qy_yzniD6m0
  b. How have some of these products changed over time? Compare and contrast current video systems such as PS4 or xBox with the Atari 2600. How has technology changed these products? What are some of the differences in "old school" and modern tech?

EXPLORE (25 - 30 MIN)

1. Show YouTube video clip about history of weatherization, highlighting old school measures: http://wxtvonline.org/2010/04/world-wx/ (00:57 - 04:51).
2. Divide students into teams of 3-4 individuals. Provide each team with the "Old School" Weatherization" worksheet. Have students describe how each measure is used and list the pros and cons for their assigned measure.

EXPLAIN (5 - 10 MIN)

- Have groups report out their results to whole class.

EXTEND/EVALUATE (15 - 20 MIN)

1. Show old school and modern Slides 12-13 from the Introduction to Weatherization PowerPoint: https://www.energy.gov/eere/wap/downloads/weatherization-installertechnician-fundamentals-20-introduction-weatherization
2. Summarize old school measures. Introduce modern measures.
3. Using the same groups of students as in the previous activity, ask groups to sort the list into the four general categories of measures: 1) building shell and insulation; 2) incidental measures; 3) mechanical systems measures; and 4) electric measures.
4. Review students' worksheets as a whole group.

RESOURCES/LINKS

DCED HOME Program: Weatherization Deferral

https://dced.pa.gov/download/home-program-appendix-3-weatherization-deferral-pilot-initiative-2017/?wpdmdl=86362&ind=0

DCED Housing Rehabilitation Guidebook

https://dced.pa.gov/download/2018-housing-rehabiliation-guidebook/

This is the World of Weatherization video

http://wxtvonline.org/2010/04/world-wx/

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Blower Door

BIG IDEA(S)

A blower door system uses air depressurization to find air leakages in the home.

OBJECTIVES

Students will:

- Describe the three major components of a door blower system
- Describe the reasons why a blower door test is used
- Identify the metrics used for measuring air leakage
- Identify methods for detecting leaks during depressurization

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

TASK LIST SUBCATEGORY

804 Identify infiltration and exfiltration points

805 Perform the energy audit procedure including set up and use of a door blower test

806 Apply math concepts to weatherization

810 Use energy efficiency industry vocabulary

OVERVIEW

The blower door system is used to measure air tightness and air leakage sites. This system uses depressurization as a way to determine leaks large and very small. This class prepares students for the Blower Door Lab.

KEY TERMS

manometer
calibrated fan
depressurization
infiltration
exfiltration
Pascal (Pa)
CFM
CFM_{50}
$CMF_{natural}$

STANDARDS

PA/SDP

3.1.12.D. Analyze scale as a way of relating concepts and ideas to one another by some measure; Analyze and apply appropriate measurement scales when collecting data.

3.2.12.D. Analyze and use the technological design process to solve problems. Assess all aspects of the problem, prioritize the necessary information and formulate questions that must be answered.

3.4.12.E7. Analyze the technologies of prefabrication and new structural materials and processes as they pertain to constructing the modern world.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 26-28, 65-67, 198

MATERIALS NEEDED

MATERIALS

- manometer
- equipment for blower door setup
- lab energy house

Technology: Video projection (optional)

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. Watch the YouTube video of the procedure: https://www.youtube.com/watch?v=icZG05XU9pM
2. Ask students to list all of the unfamiliar words they hear during the video

EXPLORE

1. Review the use of a blower door and key concepts.
2. After presenting concepts, ask *Think about house construction. Using your experience and guesses, what are the most common leakage areas in a house.* Take answers and highlight those that are common and add leakage points that didn't come up.

EXPLAIN

- Review the Key Concepts inset on p. 27. Use equipment for blower door if available to demonstrate key features, weight, as well as manometer

EXTEND/EVALUATE

1. Provide pre-drafted examples of rate of air leakage metrics and what variables are used in determining whether a house is leaky or not.
2. List ways auditors use to find different kinds of air leaks and how they might or might not be addressed.

RESOURCES/LINKS

Smoke emitters for determining leaks:

https://www.youtube.com/watch?v=UB9_62qJSHo

Energy Audit Equipment: Good overview of all equipment used in all categories, starting with the Blower door:

https://www.energyauditingblog.com/energy-audit-equipment/

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

LESSON

Blower Door Lab

BIG IDEA(S)

A blower door system uses air depressurization to find air leakages in the home.

OBJECTIVES

Students will:

- Correctly determine home safety, set up a blower door, set up a manometer, operate the blower door
- Accurately use a manometer to measure pressure differences in Pascals between inside and outside of the house
- Find an example of infiltration using appropriate tools (skin sensation, smoke wand, infrared gun, etc.)
- Calculate overall air leakage

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

TASK LIST SUBCATEGORY

805 Perform the energy audit procedure including set up and use of a blower door test

OVERVIEW

The Blower Door is special equipment that building analysts use when evaluating a home's energy performance. A large fan is place on an exterior door to measure the leakiness of the house by depressuring the interior and blowing the air outside. Using special tools, the analyst determines the location and estimates the size of leaks.

KEY TERMS

manometer
calibrated fan
depressurization
infiltration
exfiltration
Pascal (Pa)
CFM
CFM_{50}
$CMF_{natural}$

STANDARDS

PA/SDP

3.1.12.D. Analyze scale as a way of relating concepts and ideas to one another by some measure; Analyze and apply appropriate measurement scales when collecting data.

3.2.12.D. Analyze and use the technological design process to solve problems. Assess all aspects of the problem, prioritize the necessary information and formulate questions that must be answered.

3.4.12.E7. Analyze the technologies of prefabrication and new structural materials and processes as they pertain to constructing the modern world.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 65-67, 198-199

MATERIALS NEEDED

Teacher Presentation: Determine optimal number of students who will be present during the lab. Repeat with additional group(s) as needed.

MATERIALS

- all blower door equipment and accessories
- lab test house

IMPLEMENTATION (LESSON PLAN)

1. Review the purpose for a blower door test
2. Display and review all parts of the equipment needed.
3. Tour the test house and discuss needed preparation and hazards for the test.
4. Demonstrate set up the blower door – encourage students to predict the steps in the process. Disassemble with the help of students and then have each student complete the installation. Have the other students watch each installation and offer coaching and feedback to their peers.
5. Set up the manometer and show the baseline reading. Review how the manometer works as you demonstrate.
6. Operate the blower door according to the procedure on p. 66-67 and demonstrate the data parameters.
7. Have students examine areas of leakage using methods demonstrated.
8. Demonstrate metric calculations based on data collected.

RESOURCES/LINKS

Blower Door Test Demo

Part I https://www.youtube.com/watch?v=67v_rTaZmOA

Part II https://www.youtube.com/watch?v=x-RKcXwB8bQ

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

LESSON

Health and Safety in the Home: Indoor Air Quality

BIG IDEA(S)

Seen and unseen moisture issues within a house can pose health concerns. It's important for a house to have adequate ventilation so that moisture does not become a problem.

OBJECTIVES

Students will:

- Describe seen and unseen contributors to indoor air pollution
- Give examples of how moisture can affect the indoor air quality
- Explain how condensation occurs in a home
- Describe how a vapor barrier protects a house from condensation and the related problems of mold, rust and building rot
- Describe how to get rid of smaller mold problems, including what PPE is required

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Health and Safety

80 MINUTES

TASK LIST SUBCATEGORY

303	Describe the use of Personal Protective Equipment (PPE)
305	Recognize and mitigate hazards
803	Identify and evaluate mechanical, electrical, plumbing and roofing systems
810	Use energy efficiency industry vocabulary

KEY TERMS

indoor air quality (IAQ)
carbon monoxide
backdraft
evaporation
condensation
dewpoint

OVERVIEW

As we learned in House as a System, moisture is a common problem that can cause unhealthful conditions. A house needs adequate ventilation so that moisture does not build up in living spaces. Unvented combustion appliances like a gas stove or a kerosene space heater creates moisture and also gives off toxic gases. A well weatherized home provides comfort and safety as well as energy efficiency. Providing a good balance is what a weatherization technician does.

STANDARDS

PA/SDP

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

3.4.10.B4. Recognize that technological development has been evolutionary, the result of a series of refinements to a basic invention.

3.4.10.D2. Diagnose a malfunctioning system and use tools, materials, and knowledge to repair it.

4.3.10.A. Describe environmental health issues: Describe how indoor pollution may affect human health; Explain how common household cleaning products are manufactured and how to dispose of their by-products after use.

DEFINITIONS OF KEY TERMS

Indoor Air Quality (IAQ): healthiness of air inside of a building related to indoor air pollution. Combustion Appliance: examples include gas stoves, kerosene space heaters, furnaces

Carbon monoxide: a by-product gas from burning fossil fuels that is toxic and has no smell

Backdraft: combustion gases that do not exhaust from a house's chimney or ventilator; when excessive can be an extreme health and safety hazard

Evaporation: when a liquid changes to a gas (opposite of condensation); a major source of water vapor

Condensation: when water in the air condenses and turns into liquid water

Dewpoint: the temperature air must reach for its water vapor to condense into a liquid

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Health and Safety

80 MINUTES

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 101-105, 215, 184

MATERIALS NEEDED

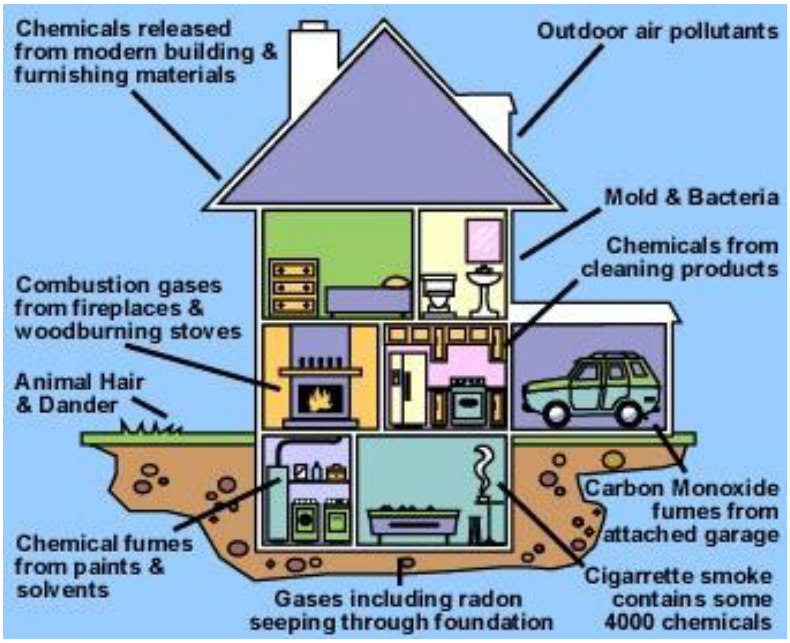
Teacher Presentation: Use of short videos.

MATERIALS

- Mold experiment materials:
  - zip bags
  - paper towels
  - sprayer with water

IMPLEMENTATION (LESSON PLAN)

1. Ask *"What contributes to poor indoor air quality? Some of these sources are obvious, like cooking odors and gases, but some are not obvious or able to be seen."* Use a T-chart to list seen and unseen contributions.
2. View the diagram on the right and compare to the T-chart. Ask *"What did you know about? What surprised you?"*
3. View one of the videos about indoor air quality (in Resources).
4. Moisture build up is a big problem because of mold growth. Condensation contributes to mold growth. This is a problem that can frequently be seen like mold on walls, bubbling paint. Mold presents a serious health risk for the inhabitants. How do we usually see mold in the bathroom? What are the best clean-up methods when you see mold? What PPE is recommended for cleaning up mold?



IMPLEMENTATION (LESSON PLAN) - CONTINUED

5. Mold is everywhere. Demonstrate mold growth: Dampen a paper towel and wipe a dusty surface with it. Spray a small amount of water in a zip bag. Place in the paper towel and close. Let it sit in a warm space and check daily for mold growth. (This can be done several days ahead of this class OR students can each do their own baggie and watch for growth).
6. Show examples of moisture problems:
    a. Moisture problems that can be seen:

    b. Unseen moisture issues:

7. Review mold clean-up procedures for small jobs in the home (p.105). Use the EPA mold abatement site for ideas and methods: https://www.epa.gov/mold/mold-cleanup-your-home
8. Moisture build up can be prevented by good weatherization. This example shows use of a vapor barrier. https://www.youtube.com/watch?v=fSdD9r5K4RU

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Health and Safety

80 MINUTES

HOMEWORK

Look for indoor air quality contributors in your own living spaces. Create a poster that shows where sources of pollution can be found and label the areas.

RESOURCES/LINKS

Indoor Air Quality 101/ Causes, Effects, Solutions (3 min.)

https://www.youtube.com/watch?v=tC__d3SeuFQ

How to Understand Indoor Air Quality: Ask This Old House. (HRV, 4:28 min.)

https://www.youtube.com/watch?v=ZRqOUcVs52

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Health and Safety

80 MINUTES

LESSON

Introduction to Principles of Energy

BIG IDEA(S)

Building Science is an approach to weatherization that uses modern technology to study building construction, maintenance, safety and durability in an effort to increase energy efficiency. In home auditing and consequent retrofit, technicians use their knowledge of the kinds and properties of energy to evaluate the properties of materials and the methods to achieve energy efficiency.

OBJECTIVES

Students will:

- Explain energy, its varieties, sources and behavior
- Explain the laws of thermodynamics and provide examples
- Explain examples of energy measurement including use of both Fahrenheit and Celsius scales
- Describe the use in weatherization of the British Thermal Unit (BTU)
- Apply energy concepts to materials and processes used in weatherization work

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

TASK LIST SUBCATEGORY

101	Explain the principles and physics of energy
801	Identify the principles of building science
809	Apply math concepts to weatherization
810	Use energy efficiency vocabulary

OVERVIEW

Energy is covered in both the solar and weatherization fields. NOTE: Some of these topics may have already been presented in prior lessons where these principles are applied. This lesson can be either an initial presentation or a review if already studied. The energy topics most important to the work of a retrofit technician include energy conservation measurement, laws of thermodynamics, forms of energy, and the heat transfer process. It is best present these energy concepts as hands-on and concrete as possible for 10th grade students.

STANDARDS

PA/SDP

3.2.C.B3. Describe the law of conservation of energy.

3.2.P.B3. Describe the factors that influence **convection, conduction,** and **radiation** between objects or regions that are at different temperatures.

3.4.10.E3. Compare and contrast the major forms of energy: thermal, radiant, electrical, mechanical, chemical, nuclear and others.

CC.3.5.9-10.A. Reading: (Specific Anchor) Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

KEY TERMS

Energy: the ability to do work

Work: the transfer of energy

Temperature: the measurement of the vibration of molecules in a substance

Celsius: a temperature scale used everywhere except the U.S.

Fahrenheit: temperature scale used in the U.S.

British Thermal Unit (BTU): the quantity of heat required to raise the temp of one pound of pure water one degree F°

1st and 2nd Laws of Thermodynamics

Delta T: difference in temperature in two areas

Heat transfer process: conduction, convection and radiation

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 106 - 110

MATERIALS NEEDED

Teacher Presentation: Print out the quiz, if using; provide projection of graphics and videos for the whole group

MATERIALS

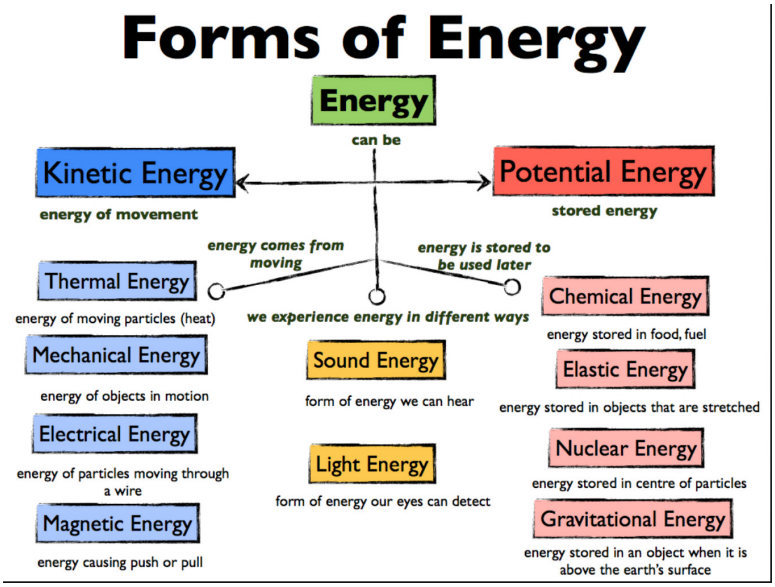
- Candle and matches to illustrate potential and kinetic energy; chemical, radiant, thermal energy
- Illuminated clear incandescent light bulbsprayer with water

Technology: Share videos and visuals in the lesson with the class

IMPLEMENTATION (LESSON PLAN)

ENGAGE

1. Use a candle and match to illustrate potential and kinetic energy, and bring in chemical (candle), radiant (light) and thermal (heat emission using a blown up balloon moving it closer to the flame to let it pop).
2. *There are two kinds of energy, potential and kinetic.* Provide a brief example of each. Have students identify what in the demo had potential and kinetic energy. Ask for a definition of each. Discuss the properties of the candle, light and heat, assessing student background knowledge. Use the chart to present the major kinds. You can build your own chart for students as you explore the main types of energy that can remain in the classroom for reference.



EXPLORE

1. Energy is the ability to do work. There are two main categories of energy: kinetic and potential. There exist different types of energy sources, some of which we will discuss in our work: thermal energy, radiant energy, chemical energy, mechanical nuclear energy, electrical energy, and radiant (solar) energy.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

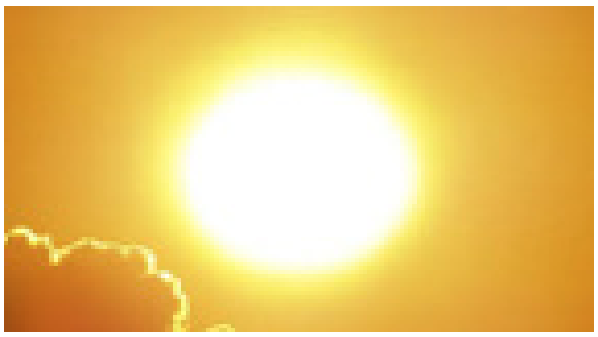
90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

2. Provide a brief example of the kinds of energy shown in the chart. The following video can be used: https://www.youtube.com/watch?v=FX7T-QYTPho

EXPLAIN

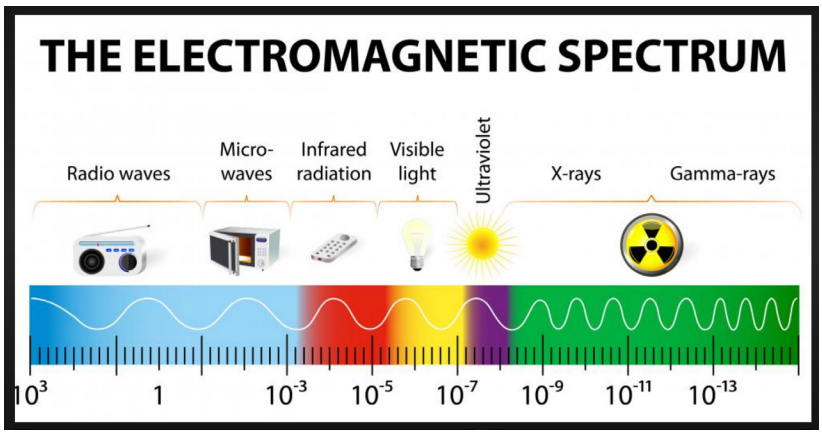
1. Review results as a whole group. Start by reviewing what energy is. Then move into any topics which may need review. The text, or attached videos, may be used with students as a refresher if needed.
2. Project the following visuals when possible:



What is energy?

- Energy = Work
- Work = Transfer of Energy
- Work is being done *ALL AROUND US, ALL THE TIME*
- 99% of our energy comes from the sun.

3. Remember that Solar Energy = Radiant Energy. Radiant energy transfer. Review the type of radiant energy on the electromagnetic spectrum and which waves have the most to do with solar and weatherization (especially insulation).
   a. Light up a clear incandescent light bulb
   b. Have students explain the radiant energy (electric energy makes the filament glow, which is heated in the process; both glow and infrared heat given off are examples of radiant energy.
   c. The sun reaching our skin is an example of pure radiation. Radiation left its source and traveled through space to warm another surface
   d. Heat and thermal energy is the most important to understand.



BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

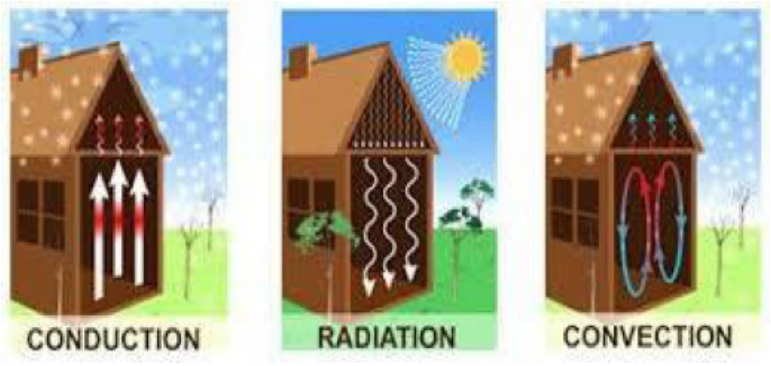
Building Sciences

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

EXTEND

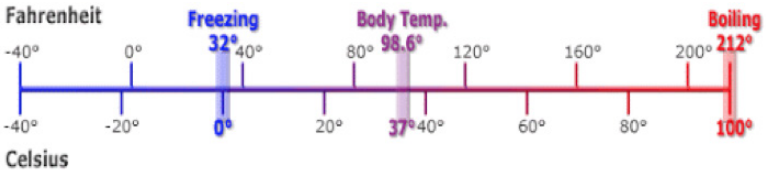
1. Review the heat transfer process. Use the heating pot and have students explain the heat transfer process. Provide support or information as needed.
2. Ask why this is the most important to understand in weatherization. (heat travels from the highest temp areas to lowest - related to air movement in a home or heat through windows and walls to the outdoors) Much of what an installer is doing is preventing heat transfer.



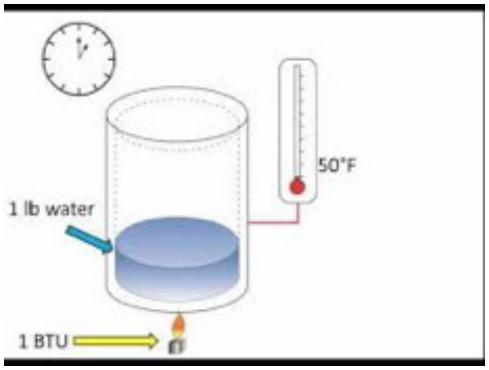
a. Additional heat transfer video and graphics can be found in the Appendix.

b. Additional resources are attached for additional topics:

i. Temperature Measurement: Celsius and Fahrenheit



ii. BTU's



iii. 1st and 2nd Laws of Thermodynamic

EVALUATE

- If most of the topics are covered, provide the quiz provided at the end of the resource section. Students should work in small groups to support each other. Use the quiz as much to clarify as to assess. Edit this quiz if some of the topics are not covered in your lesson.

BRIGHT SOLAR FUTURES

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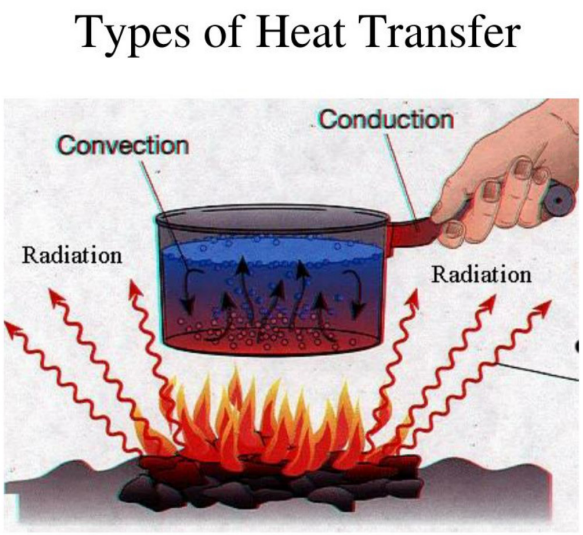
RESOURCES/LINKS

Potential and Kinetic Energy Quiz: can be used to explain rather than assess.

https://www.proprofs.com/quiz-school/story.php?title=potential-kinetic-energy

Principles of Heat Transfer

https://www.bpihomeowner.org/blog/technically-speaking-principles-heat-transfer



Types of Heat Transfer and How Insulation Works to Prevent Heat Transfer (Good insulation visuals)

https://www.youtube.com/watch?v=kB7ZeiHnEBw

Overview of Energy

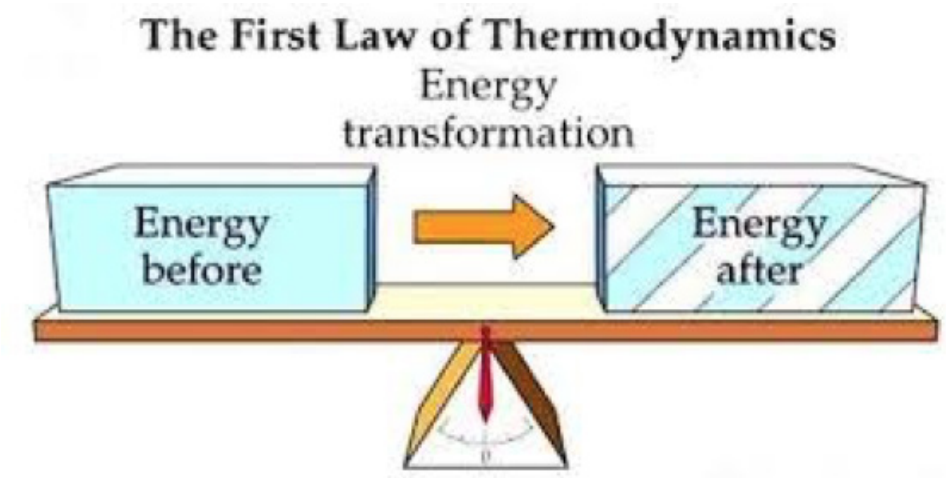
https://www.need.org/Files/curriculum/infobook/IntroS.pdf

1st and 2nd Laws of Thermodynamics

https://www.youtube.com/watch?v=v4zpQcAY5Eg

First Law of Thermodynamics:

https://www.youtube.com/watch?v=-8hpSl2MeyA



BRIGHT SOLAR FUTURES

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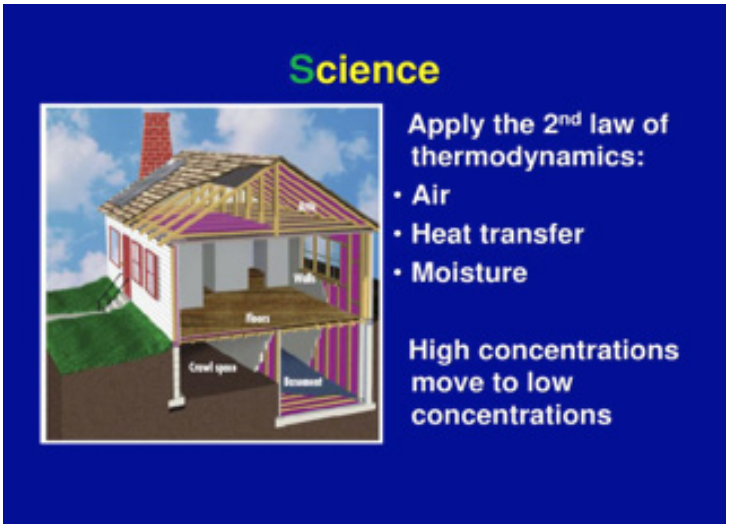
Building Sciences

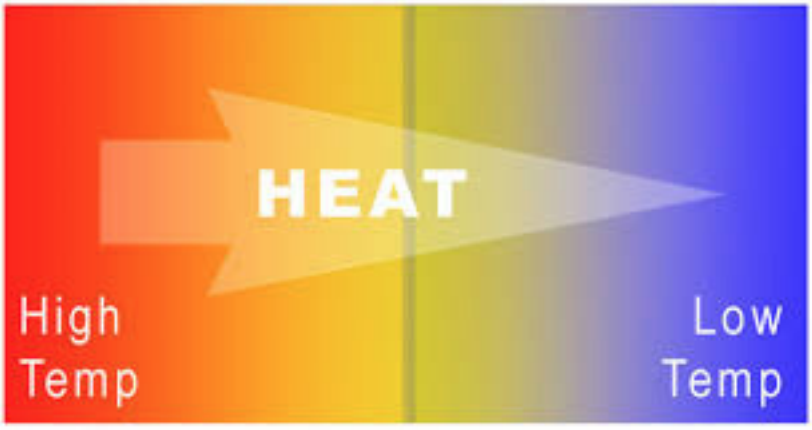
90 MINUTES

RESOURCES/LINKS (CONTINUED)

Second Law of Thermodynamics/Entropy

https://www.youtube.com/watch?v=DWiCaDPM7Hk





British Thermal Units

https://www.youtube.com/watch?v=OCrrQZ0ZjLs

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

RESOURCES/LINKS (CONTINUED)

ENERGY QUIZ

1. What type of energy does the SUN give?
   - A. Mechanical
   - B. Electrical
   - C. Solar
   - D. Sound
   - E. None of the above
2. What three processes make up the heat transfer process?
   - A. Condensation, Convection, Confusion
   - B. Conduction, Pressurization, Condensation
   - C. Combustion, Condensation, Radiation
   - D. Conduction, Convection, Radiation
   - E. None of the above
3. What is true about energy?
   - A. It is the ability to do work
   - B. It cannot be created
   - C. It cannot be destroyed
   - D. Energy depends on sunlight
   - E. All of the above
4. When functioning, what type of energy does a gas heater have?
   - A. Nuclear
   - B. Chemical
   - C. Thermal
   - D. Mechanical
   - E. None of the above
5. What is true about the 2nd Law of Thermodynamics?
   - A. Total energy stays the same
   - B. Sound waves can cause heat
   - C. Energy goes from low temp areas to high temp areas
   - D. Energy goes from high temp areas to lower temp areas
   - E. None of the above
6. What is true about the 1st Law of Thermodynamics?
   - A. Energy can't be created
   - B. Energy can't be destroyed
   - C. Energy changes from one form to another
   - D. Total energy in a system remains the same
   - E. All of the above

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

RESOURCES/LINKS (CONTINUED)

7. What energy does fire have?
    A. Chemical
    B. Nuclear
    C. Thermal
    D. Kinetic
    E. None of the above
8. Celsius and Fahrenheit are both examples of
    A. Potential energy
    B. Mechanical measurement
    C. Nuclear energy
    D. Temperature measurement
    E. None of the above
9. Light bulbs show off what type of energy?
    A. Radiant
    B. Chemical
    C. Electrical
    D. Sound
    E. None of the above
10. Delta T is the difference in:
    A. The air pressure of two areas
    B. The wind speed in two areas
    C. The difference in temperature in two areas
    D. The vibration of molecules in two areas
    E. None of the above
11. Temperature is:
    A. Hotness or coldness
    B. The measurement of the vibration of molecules
    C. A determination of internal energy
    D. A reading on a Fahrenheit thermometer
    E. All of the above
12. A British Thermal Unit is a quantity of heat needed:
    A. to raise air pressure of a room
    B. to increase temperature
    C. to make you feel warm
    D. to decrease temperature
    E. None of the above

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Air Movement: Driving Forces

BIG IDEA(S)

The control of air movement is the main purpose of weatherization.

OBJECTIVES

Students will:

- Summarize the causes of air movement in a house
- Differentiate wind, stack and mechanical effect
- Explain how Delta P and Delta T contribute to air leakage

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

TASK LIST SUBCATEGORY

101	Explain the principles and physics of energy
109	Demonstrate strong reading comprehension for use in relevant texts and websites
801	Identify the principles of building science
802	Describe the interconnection of systems using the "House as a System" framework
804	Identify infiltration and exfiltration points
810	Use energy efficiency industry vocabulary

OVERVIEW

The control of air movement is the main purpose of weatherization. Once a house is determined to be safe and healthy, controlling air and temperature movement is the most important task. This lesson covers both pressure and temperature causes of air movement through looking at rate ($CFM_{natural}$), and common home conditions: wind, stack, and mechanical effects.

KEY TERMS

Delta P: Difference of pressure in two areas, air flowing from the high pressure to the lower. In winter, delta P is high inside and lower outside.

$CFM_{natural}$: Cubic feet per minute measure of air leakage under normal conditions

Wind Effect

Stack Effect

Mechanical Effect

Combustion Air: air that combines with fuel to produce head

Flue: a pipe that vents combustion exhaust from an appliance to outside

STANDARDS

PA/SDP

3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of **convection, conduction,** and **radiation** between objects or regions that are at different temperatures.

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 111 - 115

MATERIALS NEEDED

Teacher Presentation: Materials for imploding can demo (Implementation Step 1)

IMPLEMENTATION (LESSON PLAN)

1. Demonstrate what a temperature change can do to air pressure.
    a. Materials: empty soda can, bowl of ice water, kitchen forceps, heat source (hot plate, gas stove, etc.)
    b. Procedure:
        i. Hold the empty can with forceps (opening at the top) over the heat source.
        ii. When can is hot, immediately turn it over into the ice water so that the can top submerges at least an inch or so.
    c. Debrief: Ask students to explain why the can collapses. Compare the interaction of heat and pressure. (As heat in can moves to cold area (entropy, 2nd law of thermos), the air moves with it causing the side of the can to respond to the decrease in pressure.
2. As we just saw, temperatures inside and outside are the main drivers of air flow. The hot air in the can moved to the cold "outside" creating enough Delta P to collapse the can. Weatherization focuses on what happens as Delta P increases, with greater air flower through bigger passages.
3. Delta T: temp difference in two different areas, the bigger the escape routes (or in cold weather the entry routes), the faster the movement. Explain $CFM_{natural}$ and seasonal differences.
4. Rate and Replacement: Explain Leakage rate. Use the graph to show the difference in treated and non-treated window.

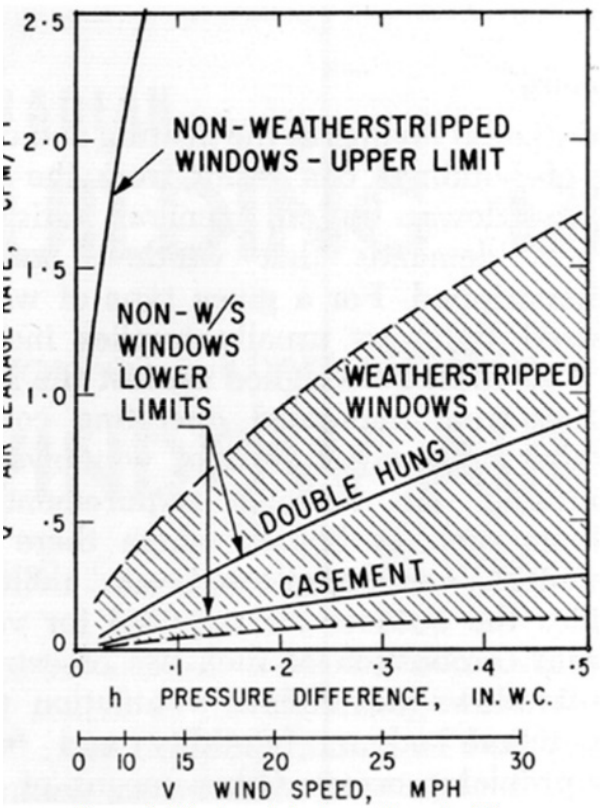


Figure 1. Window air leakage characteristics

BRIGHT SOLAR FUTURES

WEATHERIZATION

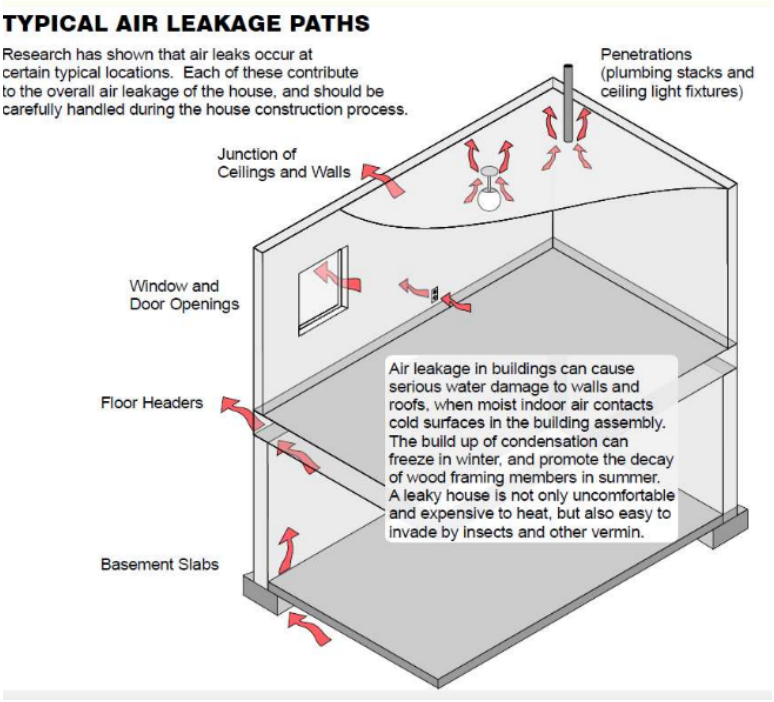
TOPIC OF STUDY

Building Sciences

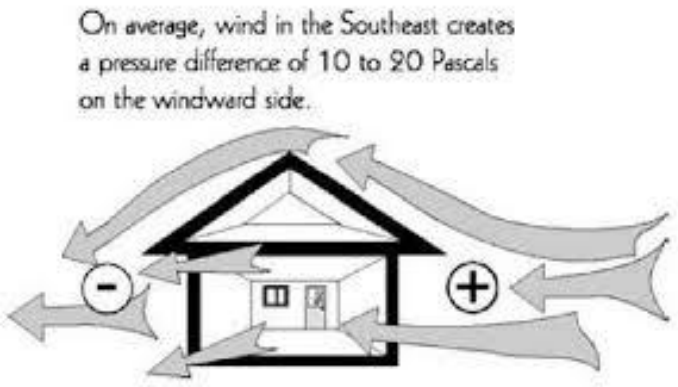
90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

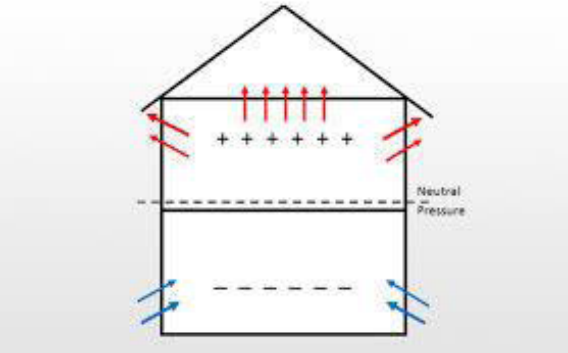
5. Direct and Indirect Air Leakage
   - Direct: vents, doors, and other intentional openings
   - Indirect: smaller, unintentional openings
   - Notice the unintentional areas.



6. Wind Effect (*Energy Conservation Handbook*, p.113)



7. Stack Effect (Review—previously presented.)



BRIGHT SOLAR FUTURES

WEATHERIZATION

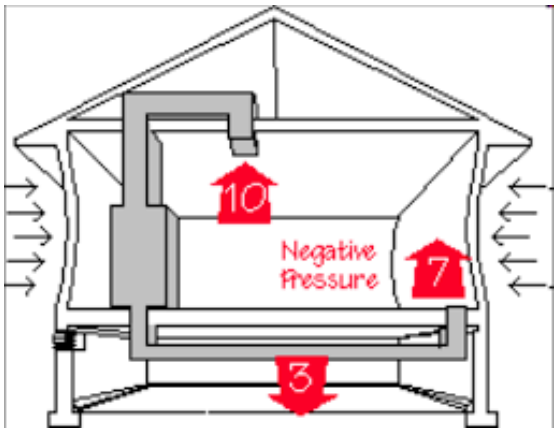
TOPIC OF STUDY

Building Sciences

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

8. Mechanical Effect (*Energy Conservation Handbook*, p.118). Below is an example of a mechanical effect from a combustion appliance.
    - Unbalanced duct systems lead to pressure imbalance:



This system pulls 10 units of air from the house, sends it back to the HVAC system where it gets heated or cooled, and then puts 10 units back into the supply ducts. In this house, the supply ducts run in an unconditioned crawl space. Of the 10 units air entering the supply ducts, only 7 make it all the way back to the house.

Simple arithmetic: If you add 7 (supply air) and take away 10 (return air), you've got a negative number. In this case, the house will experience negative pressure due to the unbalanced duct leakage. That negative pressure will result in making up those 3 missing units of supply air with air that infiltrates from outside the house. It may be from the crawl space. It may be from the attached garage. It may be from the attic.

HOMEWORK

Use an internet search to find what is recommended to combat one of the effects (wind, stack, mechanical).

RESOURCES/LINKS

Another way to express the rate of air change in a house is ACHn - natural air changes per hour. This is the number of times the air is changed in a home (or space) per hour under natural conditions. This term is not unique to us energy auditors and is used by engineers to design make-up air for buildings. Each building has a target ACH it has to reach per code. For homes, ACH is a nice term for homeowners to hear and relate to, rather than CFM. One ACH means that all the air in the house is replaced one time every hour.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Air Leakage

BIG IDEA(S)

Unwanted air leakage is the primary cause of energy inefficiency.

OBJECTIVES

Students will:

- Make observations and compare rates of air leakage in balloon model
- After exploring air leakage in a balloon model, apply the concept of air leakage to homes
- Identify potential points of air leakage
- Relate the issue of air leakage to financial loss
- Summarize basic principles of air leakage

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

TASK LIST SUBCATEGORY

804 Identify infiltration and exfiltration points

810 Use energy efficiency industry vocabulary

OVERVIEW

All homes breathe, but most homes breathe too much. Unwanted air leakage, is the primary cause of energy inefficiency. Addressing air leakage problems is the second most important priority after health and safety. The unintentional introduction of air into a building is known as air infiltration.

KEY TERMS

infiltration
exfiltration
ventilation
conditioned system

STANDARDS

PA/SDP

3.2.12.A9. Formulate and revise explanations and models using logic and evidence.

3.2.12.B2. Explain how energy flowing through an open **system** can be lost.

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 96 - 101

MATERIALS NEEDED

Content: Air Leakage Assessment Worksheet

MATERIALS

- Timer
- 3 balloons per pair of students with pinholes prepared in advance

Technology: Access to YouTube

IMPLEMENTATION (LESSON PLAN)

ENGAGE

- Quick leakage general introduction: Family Feud style game/whole class questioning – Name top 5 things you would not want to leak. (roof, toilet, baby's diaper, change/money in your pocket, soda, food, air from a car/bike tire, data/information). Ask students why they would not want these things to leak? (damage = money loss).

EXPLORE

1. Give each team of students three balloons: one with no pinholes, one with a single pinhole, and one with 5 pinholes.
2. Ask students to blow up and tie off one of the balloons. Using a timer on their phone or a provided timer, students should Immediately begin to make observations of the balloon for a 1 minute period. At the end of the 1 minute period students should record the approximate amount of deflation (0%, 25%, 50%, 100%) in a data table. Repeat the trials three times.
3. Ask students to repeat the above steps with the remaining two balloons.
4. Ask students to record what they think happened.

EXPLAIN

1. Student teams report back results to whole group, explaining results.
2. Ask students to create a definition of the terms "infiltration" and "exfiltration."

EXTEND

1. Ask students to apply the balloon air leakage results to a house. If the house is leaking warm air in the winter, how does this impact the owner's energy bill?
2. Show first 6 min 30 seconds of YouTube video: https://youtu.be/dgl4UTpdMtE

EVALUATE

- Use the Air Leakage Assessment Worksheet.

RESOURCES/LINKS

Ohio State University Extension Green Home Technology Center

https://greenhome.osu.edu/reduced-air-infiltration

Finding Air Leakages by Qualibuild

https://youtu.be/dgl4UTpdMtE

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Air Sealing Method: Introduction to Insulation

BIG IDEA(S)

Air sealing and insulation aid in the control of air movement.

OBJECTIVES

Students will:

- Review their understanding of infiltration, exfiltration, and ventilation as a base for air sealing techniques
- Describe the main categories of air sealing materials and insulation
- Identify specific materials and insulation for specified criteria of air and heat leakage jobs
- Understand the health and safety hazards of air sealing and insulation materials and the PPE needed when using them

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

804 Identify infiltration and exfiltration points

806 Understand weatherization task including air sealing and insulation

810 Use energy efficiency industry vocabulary

OVERVIEW

A healthy house has some infiltration and exfiltration of air, or "breathing." Too many air leaks can cause moisture and dust to enter. A house that is too tight will be humid and may have moisture problems. Weatherization requires the knowledge to diagnose what the leakage problems are and to choose the proper air sealing or insulation materials. Air sealing and insulation are often needed to stop air movement. It is also critical to understand the properties of all materials to employ proper PPE.

KEY TERMS

Thermal envelope: the part of the house that separates the "conditioned" from the "unconditioned" space.

Air barrier: parts of the exterior wall that resists air infiltration or exfiltration

Building cavities: empty space inside wall, floors, or ceilings and between the outside shell (bricks, sheathing, etc.) and the interior walls. Older houses usually have no insulation in this space.

Natural ventilation: no use of mechanical or electrical equipment e.g. opening a door or window

STANDARDS

PA/SDP

3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

CC.3.5.9-10.A. Reading Specific Anchor (Key Ideas and Details): Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

NGSS

NGSS HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 28-31, 47-54

MATERIALS NEEDED

Content:

- Caulk gun ready for a sealing task; materials for demo seal
- One part expanding spray foam for a cross section showing a gap to be filled
- Other examples of materials available on display and places to use them (virtual presentation or on site walk-about)
- Opportunities for students to practice (optional)

Technology: Computer with internet access for viewing videos

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

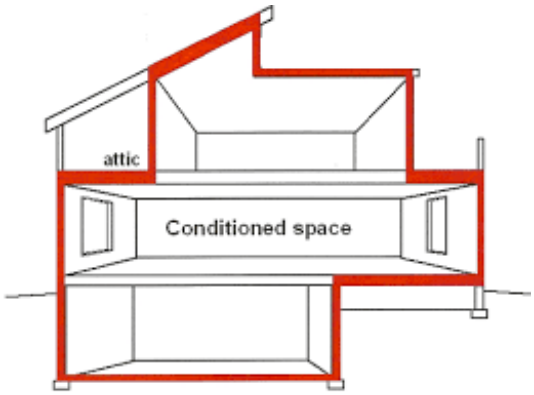
Weatherization

90 MINUTES

IMPLEMENTATION (LESSON PLAN)

1. Review: Air Barriers, Building Envelope

   Air within the envelope of a building is subject to air infiltration, exfiltration and the three modes of heat transfer: conduction, convection and radiation. Insulating materials address heat transfer through all three modes; however, the benefits can be lost, sometimes completely, if air infiltrates the envelope. Combined with other classes of insulation, such as spray foam, batt and rigid board insulation, air barriers can provide a solution—plus additional thermal performance (R-value) for homes and commercial buildings when installed facing an enclosed air cavity and/or air film.



2. View a short video that shows some of the ways homes can we weatherized as part of the WAP program. https://www.youtube.com/watch?v=-YHg0fK4XY4
3. Debrief
   a. *What locations were seen as the most important to weatherize?*
   b. *What materials were installed?*
4. Weatherization Materials (*Energy Conservation Handbook*, pp. 47-54). Review materials. Choose a few to demo that there is time for and the most commonly used. Use video to get an overview: https://www.youtube.com/watch?v=PYOhxK0yauE
   a. Introduce:
      i. The primary materials used in weatherization.
      ii. What they are used for
      iii. How to apply them
      iv. Safety considerations for each one

IMPLEMENTATION (LESSON PLAN) - CONTINUED

5. Sample Demo: Applying caulk. https://www.osha.gov/Publications/OSHA3514.html How many students have already used a caulk gun? What are some possible challenges. What safety precautions were taken or not taken. If live demo rather than video, break down in safety, prep, application, cleanup.
6. Introduce MSDS: Materials Safety Data Sheets for sample products that you will demonstrate and choose the appropriate PPE, in this case for caulking. Review with students. https://media.toolboxsupply.com/media/downloads/12658/10612180.pdf
7. Caulk (or other weatherproofing material) student hands-on: provide materials and PPE for students. Organize in groups of two or three. Each group debriefs when practice is completed.

RESOURCES/LINKS

Spray Foam Insulation

https://www.youtube.com/watch?v=TdlSYMuwq-I

Different types of spray foam

https://www.youtube.com/watch?v=tmaWC7ZkVi8

OSHA Brief: Hazard Communication Standard: Safety Data Sheets: Good for teacher background but way too technical for students at this point. May be revisited in year 2 or 3. Focus on MSDS for specific products demonstrated.

https://www.osha.gov/Publications/OSHA3514.html

Weatherize with Caulk and Weather Strip

https://www.nrel.gov/docs/fy01osti/28039.pdf

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Thermal Boundary

BIG IDEA(S)

A thermal boundary includes an air boundary (through sealing) and insulation material.

OBJECTIVES

Students will:

- Describe how insulation works with regard to conduction, convection and radiation.
- Describe the factors involved in choosing insulation based on priority need, climate, house condition, etc.
- Distinguish the effectiveness of different kinds of insulation
- Describe install procedures along with necessary safety measures

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

3 HOURS
(TWO CLASSES)

TASK LIST SUBCATEGORY

802 Describe the interconnection of systems using the "House as a System" framework

806 Perform weatherization tasks including air sealing, moisture barriers, and insulation

810 Use energy efficiency industry vocabulary

OVERVIEW

A good thermal boundary for a house includes a good air boundary (through sealing) and insulation material. While air barriers prevent convective flow, insulation prevents conductive heat transfer as well as convective and radiant heat transfer. Insulation helps to slow heat loss and is good to install anywhere heat flow is to be controlled.

KEY TERMS

R-Value
thermal bridge
fiberglass
cellulose
facings
barriers
polystyrene

STANDARDS

PA/SDP

3.2.P.B3. Analyze the factors that influence **convection, conduction,** and **radiation** between objects or regions that are at different temperatures.

3.4.10.B1. Compare and contrast how the use of **technology** involves weighing the trade-offs between the positive and negative effects.

3.4.10.D2. Diagnose a malfunctioning system and use tools, materials, and knowledge to repair it.

NGSS: SCIENCE AND ENGINEERING PRACTICES - DEVELOPING AND USING MODELS

- Use a model to predict the relationships between systems or between components of a system.
- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 205-214; Quiz 265-66

MATERIALS NEEDED

MATERIALS

- Samples of insulation:
  - Fiberglass: faced and unfaced batts; loose fill
  - Cellulose
  - Rigid insulation panels: choose a variety that represent diversity of application and material (*Energy Conservation Handbook*, p. 210-211)
- Materials for insulating experiment

Technology: Computer with access to YouTube

IMPLEMENTATION (LESSON PLAN)

1. *Stop Heat from Escaping Experiment*: https://www.youtube.com/watch?v=Yg8kXf_HKtU

   Materials needed
   - 4 empty plastic water bottles with lids
   - 4 kinds of insulating materials: Newpaper (cellulose), aluminum foil, plastic trash bag, wool sock (or any materials that you can wrap around the plastic bottles)
   - Digital scale, scissors
   - Masking tape
   - Thermometric with wire probe
   - Enough hot water to fill the 4 bottles (not so hot that it collapses the bottles)

   Procedure
   - To keep the results consistent, use the same amount of each insulator. Use mass area or thickness as your standards. For mass, use the scale and start with the sock since you can't cut it so easily to change the mass.
   - Wrap each bottle up to the cap area and secure with tape.
   - PREDICT which will insulate the best. On the board chart the 4 choices of each student's predictions in order from best insulator to poorest (1-4).
   - Fill each bottle with the hot water and take the temp of each bottle
   - Close the bottles and wait 15 minutes
   - Check the temperatures again. List in descending order of which help the most heat 1-4.
   - Have students check their predictions.
   - Discuss whether the loss of heat to the cooler outside is an example of conduction, convection, or radiation.
2. Ask *"How does insulation work? Explain what happened in our experiment."* Review R-Value and the idea that insulation works primarily through conductive resistance (*Energy Conservation Handbook*, pp. 205-206).

BRIGHT SOLAR FUTURES

WEATHERIZATION

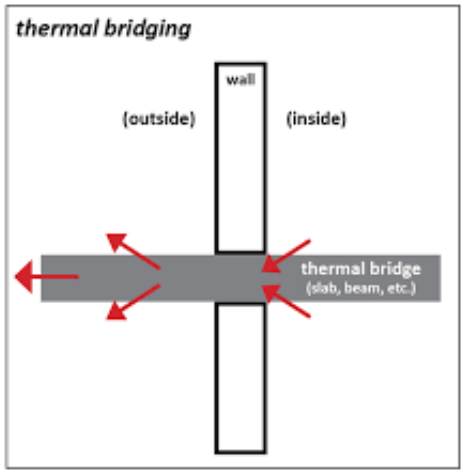
TOPIC OF STUDY

Building Sciences

3 HOURS
(TWO CLASSES)

IMPLEMENTATION (LESSON PLAN) - CONTINUED

3. Thermal bridges allow rapid conductive heat transfer and can be found within an area of higher thermal resistance, like a screw used to secure insulation batting, or as in the picture, something that traverses a wall.



4. Discuss how insulation is chosen based on climate areas, and in cases such as the far South, installed differently. (*Energy Conservation Handbook*: Map pg. 208; Chart for Vapor Barriers, p. 213).
5. Types of insulation: Show students samples of the insulation you have chosen, describing composition, properties, primary uses. Indicate which insulation is used mostly in retrofit and which is better in new construction (See appended DOE chart: Types of Insulation OR Use the Chart on p. 214)
6. Show how facings and barriers support insulation.
7. Insulation Quiz: *Energy Conservation Handbook*, pp. 265-266

RESOURCES/LINKS

Conduction, Convection, Radiation and Insulation

https://www.youtube.com/watch?v=aaUz_SqOXnI

This Old House Insulation (Vapor barrier, vapor retarder; new construction vs. retrofit; r-values, various materials)

https://www.youtube.com/watch?v=OJ9u3pDQeM4

Comparison of Fiberglass, Cellulose and Foam Insulation

https://www.youtube.com/watch?v=osWeSqCXpcE

Types of Insulation (DOE)

https://www.energy.gov/energysaver/weatherize/insulation/types-insulation
This is a very well organized presentation and presents costs as well. The following is taken from this source.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

3 HOURS
(TWO CLASSES)

RESOURCES/LINKS (CONTINUED)

TYPES OF INSULATION

TYPE	MATERIAL	WHERE APPLICABLE	INSTALLATION METHODS	ADVANTAGES
Blanket: batts and rolls	Fiberglass Mineral (rock or slag) wool Plastic fibers Natural fibers	Unfinished walls, including foundation walls Floors and ceilings	Fitted between studs, joists, and beams.	Do-it-yourself. Suited for standard stud and joist spacing that is relatively free from obstructions. Relatively inexpensive.
Concrete block insulation and insulating concrete blocks	Foam board, to be placed on outside of wall (usually new construction) or inside of wall (existing homes): Some manufacturers incorporate foam beads or air into the concrete mix to increase R-values	Unfinished walls, including foundation walls New construction or major renovations Walls (insulating concrete blocks)	Require specialized skills Insulating concrete blocks are sometimes stacked without mortar (dry-stacked) and surface bonded.	Insulating cores increases wall R-value. Insulating outside of concrete block wall places mass inside conditioned space, which can moderate indoor temperatures. Autoclaved aerated concrete and autoclaved cellular concrete masonry units have 10 times the insulating value of conventional concrete.
Foam board or rigid foam	Polystyrene Polyisocyanurate Polyurethane	Unfinished walls, including foundation walls Floors and ceilings Unvented low-slope roofs	Interior applications: must be covered with 1/2-inch gypsum board or other building-code approved material for fire safety. Exterior applications: must be covered with weatherproof facing.	High insulating value for relatively little thickness. Can block thermal short circuits when installed continuously over frames or joists.
Insulating concrete forms (ICFs)	Foam boards or foam blocks	Unfinished walls, including foundation walls for new construction	Installed as part of the building structure.	Insulation is literally built into the home's walls, creating high thermal resistance.
Loose-fill and blown-in	Cellulose Fiberglass Mineral (rock or slag) wool	Enclosed existing wall or open new wall cavities Unfinished attic floors Other hard-to-reach places	Blown into place using special equipment, sometimes poured in.	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.
Reflective system	Foil-faced kraft paper, plastic film, polyethylene bubbles, or cardboard	Unfinished walls, ceilings, and floors	Foils, films, or papers fitted between wood-frame studs, joists, rafters, and beams.	Do-it-yourself. Suitable for framing at standard spacing. Bubble-form suitable if framing is irregular or if obstructions are present. Most effective at preventing downward heat flow, effectiveness depends on spacing.
Rigid fibrous or fiber insulation	Fiberglass Mineral (rock or slag) wool	Ducts in unconditioned spaces Other places requiring insulation that can withstand high temperatures	HVAC contractors fabricate the insulation into ducts either at their shops or at the job sites.	Can withstand high temperatures.
Sprayed foam and foamed-in-place	Cementitious Phenolic Polyisocyanurate Polyurethane	Enclosed existing wall Open new wall cavities Unfinished attic floors	Applied using small spray containers or in larger quantities as a pressure sprayed (foamed-in-place) product.	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.
Structural insulated panels (SIPs)	Foam board or liquid foam insulation core Straw core insulation	Unfinished walls, ceilings, floors, and roofs for new construction	Construction workers fit SIPs together to form walls and roof of a house.	SIP-built houses provide superior and uniform insulation compared to more traditional construction methods; they also take less time to build.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

3 HOURS
(TWO CLASSES)

LESSON

LAB: Air Sealing Holes, Cracks, and Large Openings

BIG IDEA(S)

Air sealing and insulation aid in the control of air movement.

OBJECTIVES

Students will:

- Identify the correct air barrier materials and sealants for specific jobs
- Describe the importance of understanding local code issues related to building readiness for work, fire code, and the where materials may and may not be installed
- Describe how to air-seal small and large openings as well as space around chimney or flue pipe
- Identify the reasons and way to clean-up, including hazardous materials, tools and equipment, and materials

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

804 Identify infiltration and exfiltration points

806 Understand weatherization task including air sealing and insulation

810 Use energy efficiency industry vocabulary

KEY TERMS

non-combustible materials (for around chimeys and flue pipes)
fire code and safety
VOCs: volatile organic compounds (solvents)

OVERVIEW

There are many possible hole configurations in the upper thermal envelope of a house which needs to be sealed. This lab follows the introduction to sealing and insulation materials and is meant to provide a demonstration or laboratory experience with sealing. It may be necessary to review the kinds of sealing materials most frequently used in weatherization with an eye toward the laboratory work planned by the teacher. It is useful to have props to be sealed. As a demonstration, one prop is needed. For a class to repeat the demo, students should work in groups of 2 with one prop per group and appropriate sealing materials.

STANDARDS

PA/SDP

3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

CC.3.5.9-10.A. Reading Specific Anchor (Key Ideas and Details): Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

STANDARDS (CONTINUED)

NGSS

NGSS HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 225 - 228

MATERIALS NEEDED

Content: Sealing Jobs Worksheet

MATERIALS

- ECA Prop Panel with slot, large opening and two circular holes (demo for air sealing) or another prop

IMPLEMENTATION (LESSON PLAN)

1. Warm-Up: Review sealing materials from Air Leakage lesson. From the photo list of sealing jobs provided in the Sealing Jobs Worksheet, choose the Tools, Consumables Needed, and Safety Equipment

   Prompt: *Let's see how much you remember about sealing and materials from previous lessons. Look at the jobs and decide what tools, consumables and PPE are needed.* Students may refer to the *Energy Conservation Handbook* (pp. 47-54 and 225-228) or just make guesses.

2. Teacher procedures for the following:
   a. Air-sealing cracks, gaps, and holes: https://www.youtube.com/watch?v=XCHHRZFUnXI
   b. Air-sealing large openings: https://www.youtube.com/watch?v=tmaWC7ZkVi8
   c. Air-sealing around chimney and flue pipe: https://www.jlconline.com/how-to/insulation/sealing-a-chimney-chase_o

3. Live Demonstration: existing panel with a variety of openings similar to what is found in basement ceilings, attics, etc.
   a. The prop shown on the right represents different opportunities to air seal and demonstrate how air sealing is done.
   b. This is the open chaseway/bypass prop. The goal is to seal all the holes. To avoid filling the line, holes and the large opening separately, cover all of the openings and seal it. Choose an air seal material like a sheetrock, plywood, gypsum board, etc. Cut it so that the material will cover just beyond ½" beyond the openings. Screw material in place. Seal around edges with caulk.

4. Review/demo clean-up of work area and storage of tools and materials.
5. Student Lab Participation: a second period might be needed to have students work on a prop that needs sealing.

BRIGHT SOLAR FUTURES

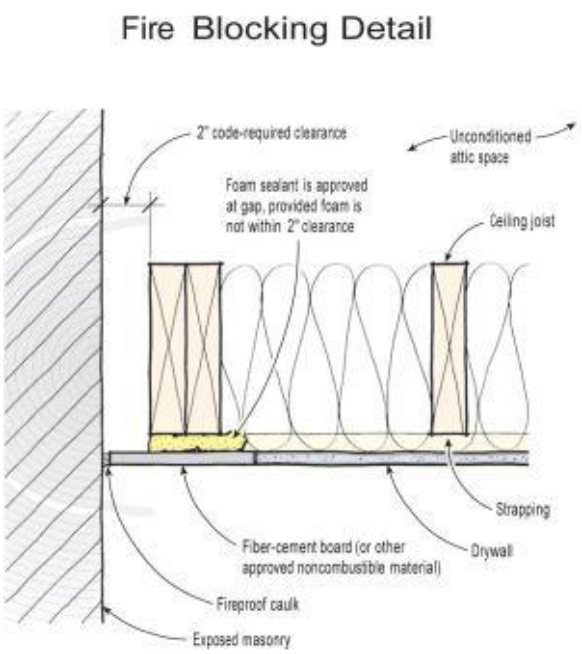
WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

RESOURCES/LINKS



When the chimney is exposed, an alternative is to cut back the ceiling drywall and patch in strips of noncombustible cement board, butting them to the masonry and sealing the gap with fireproof caulk (see illustration, left). Fire blocking is required at each level, at either the top or bottom of the joists, whereas draft-stopping is important primarily at insulated ceilings and floors that are part of the home's thermal boundary.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

LAB: Sealing the Rim or Band Joists

BIG IDEA(S)

Uninsulated rim joists allow a great deal of heat loss in a house.

OBJECTIVES

Students will:

- Identify a rim joist and describe how it transmits heat when not insulated
- Use a utility knife, a caulk gun or foam canister to seal the insulation
- Properly dispose of trash and put away materials

TASK LIST SUBCATEGORY

804 Identify infiltration and exfiltration points

806 Understand weatherization task including air sealing and insulation

810 Use energy efficiency industry vocabulary

OVERVIEW

Uninsulated rim joists allow a great deal of heat loss in a house. There are several kinds of materials to use for this application. This lab is a continuation of *Lesson 22: Air Sealing Holes, Cracks and Large Openings* which is a demonstration in Year 1. This lab is presented as a hands-on sealing opportunity for students and uses rigid foam board and, depending on the width of the crack around the foam board, a chance to seal with spray foam or caulk.

STANDARDS

PA/SDP

3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

NGSS

NGSS HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 73 - 75

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

KEY TERMS

Band/rim joist: band joists are the same as rim joists and are the boards at the end of the floor joists that wrap around the house (photo provided

Rigid foamboard: extruded polystyrene (think white coffee cups or clam-shell containers for take away). A 2" think board has an R-10 rating. Can be pink, blue or white.

INSTRUCTIONAL (CONTINUED)

MATERIALS NEEDED

MATERIALS

- Tools, consumables and safety equipment listed in *Energy Conservation Handbook*, p. 74

Technology: Computer with internet access for YouTube video

IMPLEMENTATION (LESSON PLAN)

1. Assemble enough tools, materials, and PPE to outfit the number of students present, who should work in pairs. Students will share in the steps of the sealing process and share cutting foam board and applying a seal.
2. Provide this video prior to the LAB. Sealing and insulating the rim joist: https://www.youtube.com/watch?v=h1UuyM0SRWM

   This is a solid review of how we lose heat through the rim joists for both platform and balloon framed houses, and demonstrates the process of sealing with foam.
3. Review how students will clean up after the install.
4. Locate the rim joist and explain how it enables heat loss.

5. Provide examples of what students will do. This foamboard is backed with foil.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

6. Once teams of two are formed, review needed tools, materials, and PPE. Demo the process paying special attention to the way to cut the foam board using the utility knife and the technique for using the caulk gun (Procedure p.74). Also, determine whether your install left a space around the board that was ¼ inch or less (caulk), 1" or less (spray foam).
7. For students whose cuts leave 1" or less gaps, demo to all how to use spray foam.
8. Allow one team to work on a sample joist and have other students fishbowl the install. Once completed, debrief with the class.
9. Allow other groups to complete the task with the props that are available.
10. Debrief the experience:
    a. What went well in your install?
    b. Was there anything that was harder than you thought it would be?
    c. For what do you need more practice?
    d. Were you able to use caulk or did you use spray foam.
11. Have students clean work area, store tools and materials.

RESOURCES/LINKS

Alternative rim joist sealing where fiberglass insulation is replaced with two-part spray foam:

https://www.youtube.com/watch?v=jLGbmjFgL9k

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Dense Pack Insulation Lab – Teacher Demo

BIG IDEA(S)

Air sealing and insulation aid in the control of air movement.

OBJECTIVES

Students will:

- Describe the steps in properly blowing cellulose insulation into existing wall cavities
- Follow and describe the steps required in completing the job
- Identify the proper safety steps and equipment required
- Describe the requirements for successfully using a blower machine

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

TASK LIST SUBCATEGORY

210 Demonstrate active listening and effective communication strategies

806 Perform weatherization tasks including installing air sealing, moisture barriers, and insulation

810 Use energy efficiency vocabulary

OVERVIEW

As a follow-up to the insulation lessons, the teacher demonstrates the procedures for blowing insulation into framed walls with a blowing machine. This lab shows how to prepare, drill and probe a will, and properly fill an uninsulated wall cavity with cellulose insulation. This is demonstrated in Year 1 since the process is complex and requires practice, which will take place in year 2. Calculations for determining weight per wall, density and the number of bundles of cellulose are optional for Year 1.

KEY TERMS

See *Energy Conservation Handbook*, p. 137

STANDARDS

PA/SDP

3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.

3.2.10.B3. Analyze the processes of **convection**, **conduction**, and **radiation** between objects or regions that are at different temperatures.

3.10.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.

3.8.10.B. Analyze how human ingenuity and technological resources satisfy specific human needs and improve the quality of life.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 137 - 142

INSTRUCTIONAL (CONTINUED)

MATERIALS NEEDED

Teacher Presentation: Detailed in the text

Content: Detailed in the text

Technology: If remote demo, head and tripod cameras should be used to capture.

IMPLEMENTATION (LESSON PLAN)

1. Before the demonstration, walk students through the steps that you will demonstrate in the classroom. Review tools, consumables, safety equipment.
2. Review all steps involved.
3. Provide the demonstration, including clean up and disposal of scraps and debris. If this demo is provided remotely, use a head and still camera to capture the experience adequately.
4. Debrief with students. Have students point out procedures that would require assistance and practice.

RESOURCES/LINKS

Dense Pack Demonstration (14:08 minutes):

https://www.youtube.com/watch?v=_Cqtky1owls

This Old House Dense Pack:

https://www.thisoldhouse.com/insulation/21016883/how-to-retrofit-cellulose-insulation

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Weatherization

90 MINUTES

LESSON

Energy Auditor Work Scope

BIG IDEA(S)

A work scope lists all the measures which will be done at a specific work site.

OBJECTIVES

Students will:

- Read a work scope document created by an energy auditor
- Identify the tasks required and use as a checklist to understand the order of prep, transport, work, and breakdown

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

TASK LIST SUBCATEGORY

313 Explain local ordinances or laws regarding safe transport of materials

801 Identify the principles of building science

810 Use energy efficiency industry vocabulary

OVERVIEW

A work scope lists all the measures which will be done at a specific work site and can identify the workers who will be doing them. Knowing how to read such a document allows an installer to make sure the right tools—and quantity—and materials are loaded for the needs of the day's work. This activity should be used in conjunction with any of the labs in the manual. For this presentation, we are using *Dense Pack Insulation Lab* as an example.

KEY TERMS

work scope
crew chief

STANDARDS

PA/SDP

3.4.10.D3. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.

Construction Career Pathway (AC-CST).

(5) Apply practices and procedures required to maintain jobsite safety.

(6) Manage relationships with internal and external parties to successfully complete construction projects.

(7) Compare and contrast the building systems and components required for a construction project.

(8) Demonstrate the construction crafts required for each phase of a construction project.

(9) Safely use and maintain appropriate tools, machinery, equipment and resources to accomplish construction project goals.

NGSS

CL Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 17, 69-71, 137-142

MATERIALS NEEDED

Teacher Presentation: Handout NREL 6 Domains of the Work Scope Appended

Content: Collect and duplicate appropriate work scope examples for students and create a work scope from a blank form.

IMPLEMENTATION (LESSON PLAN)

1. The work scope (or scope of work) must be complete and understandable. It must delineate the entire scope of work to be performed and specify all the tasks within that scope. Any scope of work must cover the following points:
    - What needs to be done
    - Who will do what
    - When it should be done
    - Where it should be done
    - How contract performance will be judged
    - The scope of work may also define how the job is to be accomplished
2. From the scope, the installer must then list all of the tools and materials that are to be loaded onto the truck. If multiple installers are to work at a site, it is important to know if there are enough tools and materials for everyone. Provide the installer job description (appended) and highlight how all the 6 domains relate to the work scope.
3. Review completed work scope forms with students that illustrate what is to be done using the insulation job on pp. 137-42. Use this lesson within a few days of the *Dense Pack Insulation Lab* in order to plan a work scope plan based on that work. Remind students that often more than one task is performed in a home on any one occasion. Since this requires the movement of the blower to a home, this might be the only job accomplished on this particular day.

RESOURCES/LINKS

Sample WAP Job Work Order Form

http://oeo.sc.gov/documents/weatherization/Work%20Plan%20Docs.pdf

Installer Task Analysis NREL (Provides a comprehensive overview of what is needed for the job.)

https://www.energy.gov/sites/prod/files/2014/01/f7/51671.pdf

Solar Crew Chief Description

https://www.irecsolarcareermap.org/jobs/solar-crew-chief

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

RESOURCES/LINKS (CONTINUED)

Retrofit Installer Technician Specifications and Content Outline

Job Description: A Retrofit Installer Technician installs energy-efficiency measures to single family or 2-4 unit-homes using a variety of building science best practices to improve, safety, comfort, durability, indoor air quality, and energy efficiency.

Domains/Tasks	
Domain I:	**Maintain safety**
Task 1:	Follow work rules of jurisdiction having authority
Task 2:	Handle materials/equipment according to manufacturer specifications
Task 3:	Handle tools according to manufacturer specifications
Domain II:	**Prepare for the job (before arriving to job site)**
Task 1:	Attend training
Task 2:	Gather materials and supplies
Task 3:	Gather tools
Domain III:	**Prepare and maintain tools and materials on-site**
Task 1:	Set up tools
Task 2:	Set up materials
Domain IV:	**Prepare and maintain job site**
Task 1:	Attend job safety meeting
Task 2:	Implement safety protocol (rigging, ventilation, blocking)
Task 3:	Use protective barriers (drop cloths)
Task 4:	Report preexisting conditions (that are not in scope)
Task 5:	Protect exterior environment
Domain V:	**Implement work scope**
Task 1:	Locate specific work areas
Task 2:	Verify access to work areas
Task 3a:	Install air sealing measures
Task 3b:	Install loose fill insulation
Task 3c:	Install or patch moisture barriers
Task 3d:	Rough in mechanical ventilation systems
Task 3e:	Identify mechanical systems
Task 3f:	Identify combustion appliance safety hazards
Task 3g:	Install dense pack insulation
Task 3h:	Install windows and doors
Task 3i:	Identify electrical installation needs (rough-in, fans)
Task 3j:	Identify plumbing installation needs
Task 3k:	Identify/install roofing and flashing installation needs
Task 4:	Clean as you go (organize)
Task 5:	Address deviations from work scope
Domain VI:	**Wrap up**
Task 1:	Pick up tools and materials
Task 2:	Clean up and close out
Task 3:	Participate in crew debriefing (after action review, post construction job review)

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Auditing

90 MINUTES

LESSON

The Basics of Combustion Analysis

BIG IDEA(S)

Combustion is a process of burning fuel that produces heat and water.

OBJECTIVES

Students will:

- Describe the effect of combustion on other components of a house system
- Identify the chemical reaction of combustion and its by products
- Describe how furnaces work in conjunction with a heat exchanger to provide heat
- Investigate air movement with combustion appliances including drafts, spillage and back-drafting
- Outline the steps and tools used in combustion analysis

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

TASK LIST SUBCATEGORY

802	Describe the interconnection of systems using the "House As a System" framework
803	Identify and evaluate mechanical, electrical, plumbing and roofing systems
805	Perform energy audit procedures
810	Use energy efficiency industry vocabulary

KEY TERMS

combustion
carbon monoxide (CO)
carbon dioxide (CO_2)
heat exchanger
combustion air
draft
spillage

OVERVIEW

Combustion is a process of burning fuel that produces heat and water. The furnace is the prime example of the important combustion appliance for space heating in a home, although others are important for cooking, drying clothes, and producing hot water. Auditing plays an important role in determining optimal heat distribution, control of draft, backdraft, spillage and consequent air quality. While chimneys and vents are important when diagnosing venting failures, it is important to look at the entire house during an audit.

STANDARDS

PA/SDP

3.2.P.B3. Analyze the factors that influence **convection**, **conduction**, and **radiation** between objects or regions that are at different temperatures.

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.10.B1. Compare and contrast how the use of **technology** involves weighing the trade-offs between the positive and negative effects.

3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.

3.4.10.E7. Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.

DEFINITIONS OF KEY TERMS

Combustion: burning, or the combination of oxygen and a fuel to produce heat

Carbon monoxide (CO): an odorless, tasteless, colorless and potentially deadly by product of combustion where fuels containing carbon are present

Carbon dioxide (CO_2): a bi-product of carbon combustion

Heat exchanger: metal component of a furnace that conducts heat from the fire and heats either a liquid or air.

Combustion air: heat provided in an appliance in order for combustion to take place

Draft: force that causes combustion gases to be removed from the chamber and out the flue

Spillage: the flow of combustion gases from a household combustion appliance that does not exit through a flue

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 191 - 196

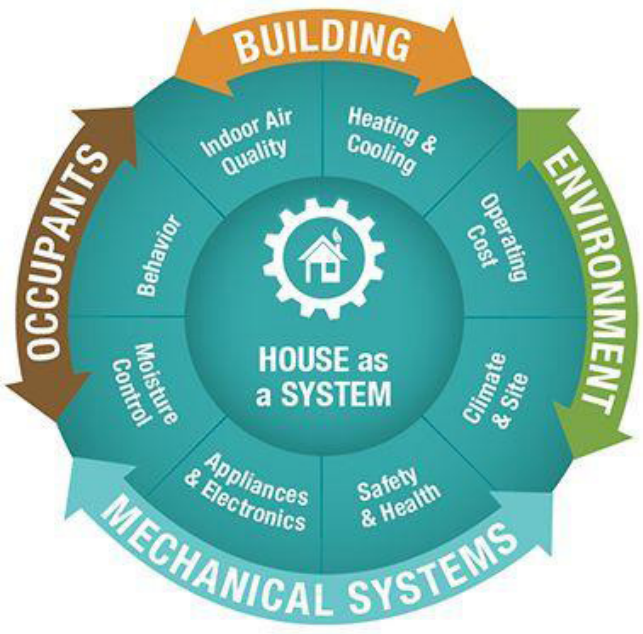
MATERIALS NEEDED

MATERIALS

- Jar with a lid
- Tea light or candle
- CO detector/monitor

IMPLEMENTATION (LESSON PLAN)

1. Review that everything we study is part of looking at a house as a system.



BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

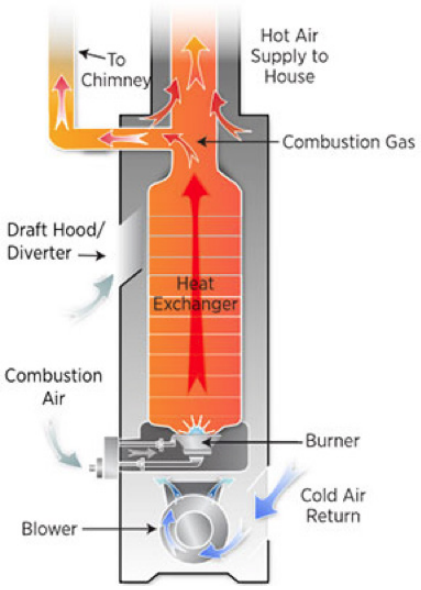
IMPLEMENTATION (LESSON PLAN) - CONTINUED

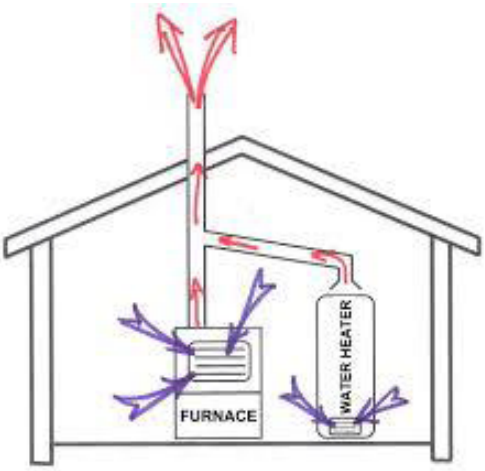
2. Combustion Demo: Using a funnel with tube, flour, lit candles, safety goggles, show the combustion of flour experiment (http://sciencedemoguy.com/science-demo-combustion/) or show the video. (If a live demo, be sure you are away from a smoke detector and wear safety goggles).

   Ask students what was necessary for the combustion to take place. Explain combustion has three requirements: fuel, oxygen, and ignition. Review the chemical formulas on p. 192 for combustion. Notice that the ingredients in natural gas reaction, $CH_4 + O_2$ has similar components as in the reaction with flour $C_6H_{10}O_5$. Both are the result of organic growth.

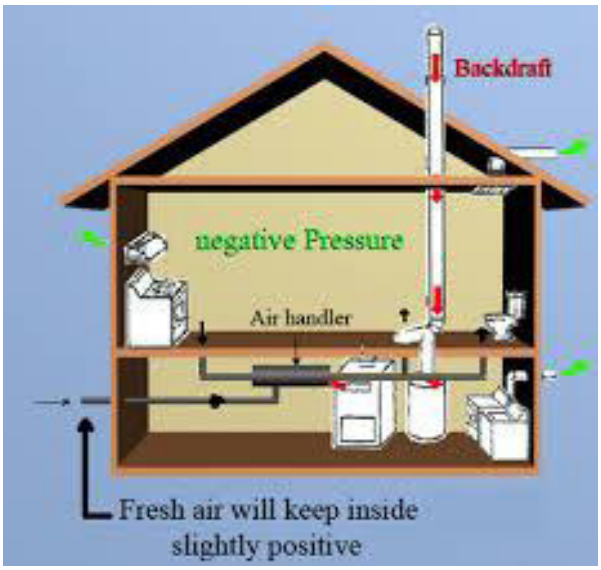
3. Describe the 5 steps of a combustion appliance using the furnace diagram from below. Explain how conduction and convection are involved in hot air systems, water heaters, hot water heating systems, clothes dryers, cooking, etc.

   Explain draft, heat distribution, cool air or water return and other aspects (*Energy Conservation Handbook*, p. 194 diagram similar to below).





Use the following to review negative pressure as a cause for back draft.



BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

4. Combustion Analysis (*Energy Conservation Handbook*, pp.195-196). Provide equipment that is used in the 8 suggested steps of the combustion audit.

Gas Leak Detector For those homes that have natural gas and propane heating systems, a gas leak detector is essential for testing gas lines.

The CD100A is the perfect serviceman's tool designed to detect combustible gas leaks in residential and small commercial applications. The semiconductor sensor responds instantaneously to all combustible gases. The easily adjusted, steady tic rate can be used in tight quarters where others might not fit.

Carbon Monoxide Detector Carbon monoxide levels need to be monitored during an audit. The heating system is checked with the combustion analyzer and this monitor tracks atmospheric CO in the house throughout the audit.

This is a Professional Series CO detector and meter with pump by FORENSICS. It is high precision for very accurate measurements and robust for field work, inspections, occupational safety, industrial and environmental applications.

Combustion Analyzer The combustion analyzer tests the efficiency of heating and hot water systems. This is a more basic model but it does the trick, testing flue gases for O_2, CO_2, heating system efficiency and carbon monoxide. It can also double as a CO detector.

RESIDENTIAL: Perfect for residential combustion analysis and ambient air quality analysis or probe sampling / continuous sampling in confined or toxic spaces.

RESOURCES/LINKS

Combustion and Energy Auditing Equipment

http://www.aee-inc.com/equipment.php

Energy Audit Equipment

https://www.energyauditingblog.com/energy-audit-equipment/

Easy to understand pamphlet of combustion and combustion appliances, problems, and maintenance:

https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-homes/combustion-gases-your-home-things-you-should-know-about-combustion-spillage/18639

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

LESSON

Energy Efficiency Strategies for Appliances

BIG IDEA(S)

Energy efficiency refers to the renovations and retrofits we do to a building to reduce the energy usage and the cost to the home or property owner.

OBJECTIVES

Students will:

- Compare usage costs of three kinds of lighting
- Describe what automatic controls can lead to energy cost reduction
- Calculate and compare energy use of appliances through power use, amount of time used, and cost of electricity
- Describe how refrigerator use can save money and when refrigerator replacement is beneficial

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

TASK LIST SUBCATEGORY

102 Describe how energy is fundamental to our everyday lives

805 Perform energy audit procedures

809 Apply math concepts to energy efficiency

810 Use energy efficiency industry vocabulary

OVERVIEW

Once baseload consumption is analyzed, technicians look for ways that energy use can be lowered. A variety of strategies can be used including repairs to appliances, replacement, and client education. Improvements in technology usually make upgrades worth the investment so students calculate use and estimated savings with replacement technologies.

KEY TERMS

Light emitting diode bulbs (LEDs)

Incandescent bulbs

Compact fluorescent lamps (CFLs)

Kill-a Watt™: audit device used to measure electric use of lighting and appliances

Efficiency: getting the same function with less energy

Conservation: using less energy by changing behavior

STANDARDS

PA/SDP

3.4.10.B1. Compare and contrast how the use of technology involves weighing the trade-offs between the positive and negative effects.

3.4.10.E7. Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.

NGSS

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

CL Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution.

CN Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 117-123, 149-152

MATERIALS NEEDED

MATERIALS

- Kill-a-Watt to measure wattage use for LED, CFL and incandescent bulbs

Technology: Computers or phones to research rebates and reduced prices for appliances on line; calculators or phones with calculator apps

IMPLEMENTATION (LESSON PLAN)

1. Have students use their phones to check in their local area or state for (1) rebates for old refrigerators that are "energy hogs", (2) cost reductions or rebates for energy efficient appliances and light bulbs.
    - Students will most likely discover that PECO in Philadelphia gives a $75 bonus for letting them take away your energy guzzling refrigerator.
    - There are discounts for buying Energy Star appliances, and they have good prices on LED bulbs, but they are expensive.
    - Discuss findings with students and ask why they think PECO, a company that sells energy, is giving out rebates for using less of their product.
2. Lighting Efficiency: Review the technology for the 3 kinds of lighting (*Energy Conservation Handbook*, pp. 118-120) and review the cost chart on p. 120.
3. Determine the energy use of each kind of bulb using a Kill-a-Watt to demonstrate in the lab. Try to keep the associated lumens (lighting output) the same for each bulb.
4. List the main findings of the Refrigerator Study (text and chart both have information).
5. Calculate the baseload savings of several appliances using LAB 5 (*Energy Conservation Handbook,* pp. 149-152). Energy Use = Power x Time — start with the chart estimates on p. 150, then use the results from the Kill-a-Watt.

    (Wattage × Hours Used Per Day) ÷ 1000 = Daily Kilowatt-hour (kWh) consumption.

    Window fan: (200 Watts × 4 hours/day × 120 days/year) ÷ 1000. = 96 kWh × 11 cents/kWh.

    Personal Computer and Monitor: [(120 Watts + 150 Watts) × 4 hours/day × 365 days/year] ÷ 1000.

HOMEWORK

1. Find out what kind of bulbs are in use where you live. Choose 5 of them and estimate what switching to LED's would save in a year using the chart on p.120 of the *Energy Conservation Handbook*.
2. Based on the refrigerator study (Blasnik, pp. 122-123), be prepared to role play an energy technician telling a homeowner the pros and cons of at least 5 features of a new refrigerator (example: refrigerators with tight freezers on the top use less energy than freezers on the bottom). Pair with another student the following day to complete the role play.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

RESOURCES/LINKS

Kill-a-Watt Use

https://www.youtube.com/watch?v=7K2uBZKLOEg

PECO Rebates

https://www.easyecoblog.com/606/peco-energy-energy-efficiency-rebates/

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

LESSON

Lighting Efficiency

BIG IDEA(S)

Energy efficiency refers to the renovations and retrofits we do to a building to reduce the energy usage and the cost to the home or property owner.

OBJECTIVES

Students will:

- Compare the cost of incandescent, CFLs and LEDs over time to determine which is most cost effective
- Use a Kill-a-Watt to determine the energy use of the three types of bulbs
- Compare results when the cost of the bulbs over an extended period is included

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
207	Perform operations in context involving fractions, decimals and percentages
805	Perform energy audit procedures
809	Apply math concepts to energy efficiency
810	Use energy efficiency industry vocabulary

OVERVIEW

This lesson is a follow-up to Lesson Energy Efficiency Strategies for Appliances and provides additional practice on calculating energy use of lighting, providing a template for determining yearly cost of the three main types of bulbs.

KEY TERMS

Light emitting diode bulbs (LEDs)

Incandescent bulbs

Compact fluorescent lamps (CFLs)

Kill-a Watt™: audit device used to measure electric use of lighting and appliances

Lumens: a unit of light given out equally in all directions; brightness

STANDARDS

PA/SDP

3.4.10.B1. Compare and contrast how the use of **technology** involves weighing the trade-offs between the positive and negative effects.

3.4.10.E7. Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.

NGSS

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

CL Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution.

CN Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 145-147

MATERIALS NEEDED

MATERIALS

- 3 kinds light bulbs
- Lamp
- Kill-a-Watt
- Other tools listed on p.145 of the *Energy Conservation Handbook*

Technology: Computers or phones to research on whether LEDs are the most cost effective bulbs.

Note: It may be a good idea to measure each bulb for electricity use with the Kill-A-Watt with the students in prior classes so that the measurements are available for the calculations required. If done in class the time measured will be much shorter.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

IMPLEMENTATION (LESSON PLAN)

1. Review the 3 kinds of bulbs. Tell students: *An older energy textbook says that "LEDs are currently too expensive to be worth the cost." The text was written in 2012. Use computer or phone to find out whether that has changed. Are LEDs currently more cost effective?* Have students present their research and evaluate how results are supported by facts.
2. Establish the cost of electricity per kilowatt hour: The average price a residential customer in the U.S. pays for electricity as of September 2020 is 13.3 cents per kWh.

   (Exploring the kinds of generation of electricity and note differences in cost vs. environmental/sustainability factor would be another possible lesson).
3. Review Lumens and Watt comparison for the 3 types:

   Compare Lumens (Brightness) to Watts (Energy Used)

LUMENS	LED WATTS	CFL WATTS	INCANDESCENT WATTS
400 - 500	6 - 7W	8 - 12W	40W
650 - 850	7 - 10W	13 - 18W	60W
1000 - 1400	12 - 13W	18 - 22W	75W
1450 - 1700+	14 - 20W	23 - 30W	100W
2700+	25 - 28W	30 - 55W	150W

4. Procedure: choose CFL, LED, and incandescent bulbs that produce the same amount of light (lumens). Test with the Kill-A-Watt for the same amount of time for each bulb. If done ahead, use a longer time like one hour. If measured for less than an hour, convert kWh used to one hour of time usage in order to calculate yearly cost in the worksheet appended. Procedure for Kill-A-Watt on p 146. Video procedure in resources.
5. Student use the appended chart to tabulate results from the light comparison activity eventually comparing the yearly cost of the bulbs.

IMPLEMENTATION (LESSON PLAN) - CONTINUED

6. Have students share their findings and compare answers in pairs. Debrief with the whole class to clarify answers.
7. For comparison, use the following chart which also includes the manufacturer's projection of the life-span of the bulb. This creates another variable for determining cost effectiveness which is not considered in the procedures. Here's how much each type of bulb would cost to purchase and operate over a 25,000-hour lifespan (about 23 years at three hours per day) based on 12 cents per kilowatt hour (2013):

	INCANDESCENT	CFL	LED
Watts used	60W	14W	7W
Average cost per bulb	$1	$2	$4 or less
Average lifespan	1,200 hours	8,000 hours	25,000 hours
Bulbs needed for 25,000 hours	21	3	1
Total purchase price of bulbs over 20 years	$21	$6	$4
Cost of electricity (25,000 hours @ $0.15kWh)	$169	$52	$30
Total estimated cost over 20 years	**$211**	**$54**	**$34**

RESOURCES/LINKS

Procedure for using a Kill-a-Watt

https://www.youtube.com/watch?v=7K2uBZKLOEg

LED Savings Calculator

https://www.viribright.com/led-savings-calculator/

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

LESSON

Basic Plumbing Applications

BIG IDEA(S)

It is important for a retrofit installer to understand some of the methods that plumbers use to identify hazards and repair needs.

OBJECTIVES

Students will:

- Identify plumbing components
- Seal plumbing penetrations
- Install low-flow showerheads
- Install pipe wrap
- Identify common plumbing hazards

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Plumbing

90 MINUTES

TASK LIST SUBCATEGORY

102 Describe how energy is fundamental to our everyday lives

303 Demonstrate the use of PPE

305 Recognize and mitigate hazards

311 Recognize, identify and safely use hand tools and power tools

803 Identify and evaluate mechanical, electrical, plumbing and roofying systems

810 Use industry vocabulary

811 Prepare and maintain tools and equipment used for energy auditing and weatherization

OVERVIEW

Installers are restricted from providing measures that require a licensed plumber and therefore act mostly as a plumbers' assistants, applying measures such as low-flow fixtures, sealing building penetrations, installing pipe wrap, and repairing thermal boundary. With that in mind, it is important for a retrofit installer to understand some of the methods that plumbers use to identify hazards and repair needs.

STANDARDS

PA/SDP

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation

4.2.10.B. Evaluate factors affecting availability of natural resources: Analyze technologies that affect the use of our natural resources.

Maintenance/Operations Career Pathway (AC-MO)

(5) Plan and practice preventative maintenance activities to service existing buildings.

(6) Maintain and inspect building systems to achieve safe and efficient operation of buildings.

Career Cluster 15: STEM. Demonstrate technical skills needed in a chosen STEM field.

KEY TERMS

Brazing: the process used to join two pieces of metal pipe using a filler metal for adhesion

Gasket: a seal which fills the space between two or more mating surfaces to prevent leakage

Teflon tape: thin tape used for installing shower heads

Pipe slope: for pipes that carry liquid or combustion gases, there are proper slope requirements depending on what is carried.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 161-163

MATERIALS NEEDED

Technology: Computer with YouTube access

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Plumbing

90 MINUTES

IMPLEMENTATION (LESSON PLAN)

1. Review safety and work site hazards (*Energy Conservation Handbook,* p. 162)
2. Evaluate worksite areas and hazards.
3. Sealing Penetrations

Through a masonry wall

Bathroom pipe penetrations

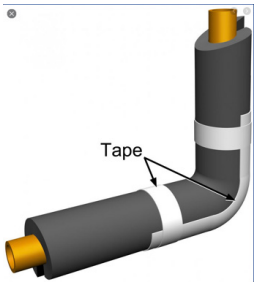
Floors and ceilings

Around raceways and chases that are usually closed with a bump-out

IMPLEMENTATION (LESSON PLAN) - CONTINUED

4. Installing pipe wrap

   Insulating hot water pipes reduces heat loss and can raise water temperature 2°F–4°F hotter than uninsulated pipes can deliver, allowing you to lower your water temperature setting. You also won't have to wait as long for hot water when you turn on a faucet or showerhead, which helps conserve water.



5. Installing low-flow shower heads
   https://blog.constellation.com/2016/07/05/average-shower-length-flowchart/

   What is a low-flow shower head? It's a shower head that is designed to reduce the amount of water that is wasted in order for your home to be more water-efficient. Shower heads can't control whether you're taking a long, luxurious shower of course, but they can help reduce your water heating costs. In fact, water heating is the second-largest energy expense for the average home. For most homes, this is about 15% of your utility bill after heating and cooling expenses. It's not just showers — hot water is used in washing machines and dishwashers too, and there are ways to cut back when using those appliances as well. Still, if you're taking the average eight-minute shower per day, you're probably using over 17 gallons of water each time.

COMPARISON OF PLUMBING FIXTURE FLOW RATES

Plumbing Fixture	Before 1992	Energy Policy Act of 1992	UPC & IPC*** Current Standards
Water Closets	4 to 7 gpf*	1.6 gpf	1.6 gpf
Urinal	3.5 to 5 gpf	1.0 gpf	1.0 gpf
Faucet (aerator)	5 to 7 gpm**	2.2 gpm	0.5 gpm
Shower head	4.5 to 8 gpm	2.5 gpm	2.5 gpm

***gallons per flush; **gallons per minute; ***Uniform Plumbing Code, International Plumbing Code**

Source: Domestic Water Conservation Technologies, Federal Energy Management Program, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, National Renewable Energy Laboratory, October 2002

- **Take shorter showers.** Even shortening a shower by one minute can save gallons of shower water usage as well as the heating costs associated with showering.
- **Install a low-flow showerhead.** Energy.gov recommends using showerheads with flow rates of less than 2.5 gallons per minute. You can choose between aerating showerheads (which mix air with water to create a misty spray) or laminar-flow showerheads, which form individual water streams. If you have any fixtures that predate 1992, replace them. Showerheads from that time had flow rates of 5.5 gallons per minute. Not sure of your showerhead's flow rate? Try this: place a bucket marked in gallon increments under your showerhead. Turn on the shower and time how many seconds it takes to fill the bucket to the one-gallon mark. If it takes fewer than 20 seconds, you could reduce your shower water usage by installing a low-flow showerhead.
- **Take a "Navy" shower.** You can reduce your shower water usage by turning off the water while you shampoo and lather up. Home Water Works estimates you can reduce your average shower length impact by as much as five minutes using this technique also known as a combat or military shower.

RESOURCES/LINKS

Home Depot: How to Change a Shower Head

https://www.youtube.com/watch?v=rzcAIb5JcXo

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Plumbing

90 MINUTES

LESSON

Domestic Hot Water

BIG IDEA(S)

Choosing a hot water heat requires understanding many variables including the need for replacement, efficiency, upfront cost, fuel cost, venting needs, amount of water demand, and life expectancy.

OBJECTIVES

Students will:

- Describe how hot water heaters (HWHs) works
- Identify and compare the parts and processes of several kinds of water heaters
- Describe how to assess the need for HWH replacement
- Describe how choosing a hot water heat requires understanding many variables including need for replacement, efficiency, upfront cost, fuel cost, venting needs, amount of water demand, life expectancy and more
- Describe the hazards associated with hot water heaters

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

TASK LIST SUBCATEGORY

102	Describe how energy is fundamental to our everyday lives
305	Recognize and mitigate hazards
803	Identify and evaluate mechanical, electrical, plumbing and roofing systems
810	Use industry vocabulary

KEY TERMS

spillage
backdrafting
corrosion
combustion air
(Vocabulary presented in schematics of hot water heater parts in the lesson)

OVERVIEW

Domestic hot water heaters (DHWs). This lesson covers how different hot water heaters work, their pros and cons, hazards associated with this combustion appliance, and additional ways to save hot water, one of the highest costs for a homeowner, about 18% of energy costs per year.

STANDARDS

PA/SDP

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation

4.2.10.B. Evaluate factors affecting availability of natural resources. Analyze technologies that affect the use of our natural resources.

Career Cluster 15: STEM. Demonstrate technical skills needed in a chosen STEM field.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook, pp. 123-131

MATERIALS NEEDED

Content: Hot water heater set up in lab, if available. Cut away of a hot water heater that shows interior work, if available.

IMPLEMENTATION (LESSON PLAN)

1. Ask: *Remember our energy use pie chart for house energy use? What percent is used for Hot Water?* List all the ways we use hot water at home (showers, washing machine, dishwasher, bathroom sink, housecleaning with hot water, etc.). It is about 18%.
2. DHW heaters use and waste of energy
    a. Tank heating
    b. Flow through pipes
    c. During standby when the tank is waiting for use
3. Assessing Condition (*Energy Conservation Handbook,* p.125 chart and p. 126)
    a. Hazards that require repair
    b. Hazards that require replacement
4. Energy saving measures
    a. Hot water temperature. For every 10 degrees you turn it down, you'll save 3% to 5% on your bill. Most water heaters come preset at 140 degrees, which has the added risk of scalding. The Energy Department recommends most households lower it to 120 degrees.
    b. Tank Insulation. If you have an older tank, and especially if it's located in an unheated space, wrapping it with an insulating blanket is a cheap and easy way to reduce costs.
        i. Manufacturers have figured this out, so most newer models already are insulated. It's easy to find out which one you have. Look on its label to see if it has an R-value of at least 24. If not, you should insulate your tank.
        ii. With these older models, an insulating blanket can cut heat loss by 25% to 45% and save 4% to 9% on the average water-heating bill.
    c. Pipe Insulation. By insulating your hot water pipes, water will arrive at the faucet 2 to 4 degrees warmer, which means you won't have to wait as long for it to heat up, thus saving energy, water, and money. While this isn't an expensive DIY job — 6-ft.-long, self-sealing sleeves ($2.50) easily slip over pipes — it could take effort, depending on where your hot water pipes are located. (See Lesson *Basic Plumbing Applications* for pipe insulation installation.)
5. Other Energy saving measures
    a. **Drain the Sediment.** Tanks naturally build up sediment, which reduces efficiency and makes saving energy a challenge. Draining the tank will keep it running efficiently. And it's really easy to do:
        i. Turn off the water and power to the unit. On a gas unit, set the burner to "pilot."
        ii. Connect a garden hose to the spigot at the base of the tank.

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

Energy Efficiency

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

iii. With the other end of the hose pointed at your floor drain, carefully lift the tank's pressure-relief valve and turn on the tank's spigot; water should begin to flow.

iv. **Tip:** While most manufacturers recommend draining the tank once or twice a year, you don't have to drain it completely; in fact, the Department of Energy recommends draining less water more often — just a quart every three months.

b. **Use Less Hot Water.** One sure way to cut hot water costs is to use less of it. Homeowners need to be educated about ways to save.

i. A family of four showering five minutes a day uses 700 gallons of water each week — a three-year supply of drinking water for one person!

ii. Simply by installing low-flow showerheads and faucet aerators ($10 to $20 each), you'll cut your hot water consumption by 25% to 60%. Plus, you'll save on your water bill. That family of four using low-flow fixtures can save 14,000 gallons of water a year.

iii. Also, make sure you use the "economy" setting on your dishwasher, and break the pre-washing habit. Modern dishwashers can handle a dirty dish. Scrape what's left of dinner into the trash or compost bin and then load. Energy Star appliances save the most energy when replacing older models. Run dishwashers when they are totally full.

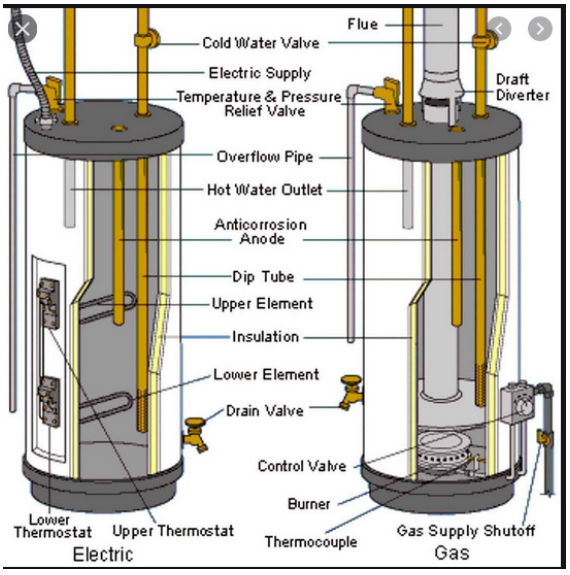
6. Kinds of water heating units (Use the graphic below to explain how each type works, advantages and costs. This video is quick but gives a great overview: https://www.youtube.com/watch?v=APHxDbCk4mc

a. Storage water heaters

i. Super-efficient, gas fired condensing HWHs save more energy but are much more expensive. The internal flue spirals around and inside the tank so that the combustion gases spend more time releasing the heat until the water vapor in the gas - a natural by-product of the combustion process - condenses, releasing even more energy. The spot where the flue exits the tank is barely warm to the touch.

ii. View this video of how a gas hot water heater works (4:01 minutes): https://www.youtube.com/watch?v=gQlatogID5c

- Electric
- Closed or Sealed Combustion



BRIGHT SOLAR FUTURES

WEATHERIZATION

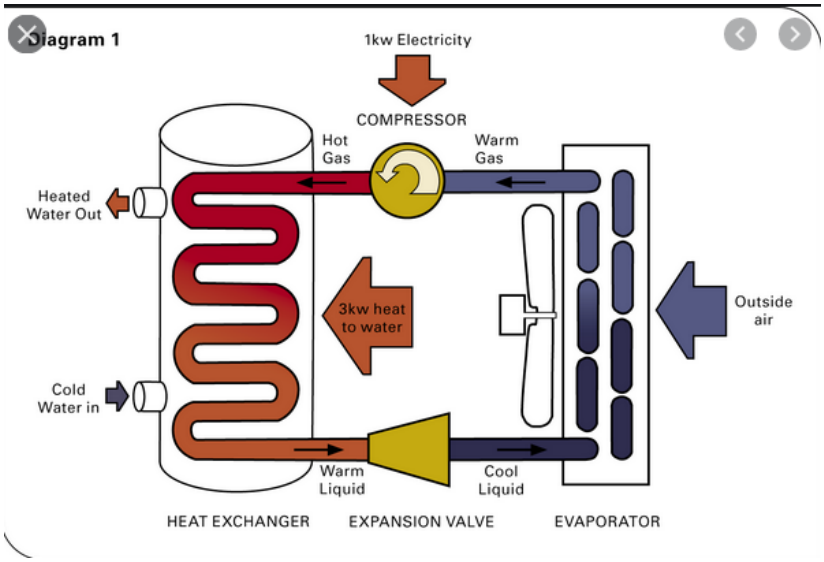
TOPIC OF STUDY

Energy Efficiency

90 MINUTES

IMPLEMENTATION (LESSON PLAN) - CONTINUED

- Heat Pump Water Heaters



BRIGHT SOLAR FUTURES

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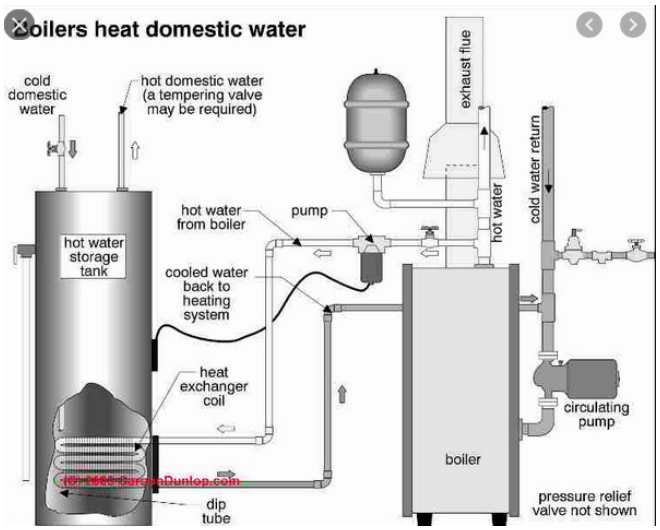
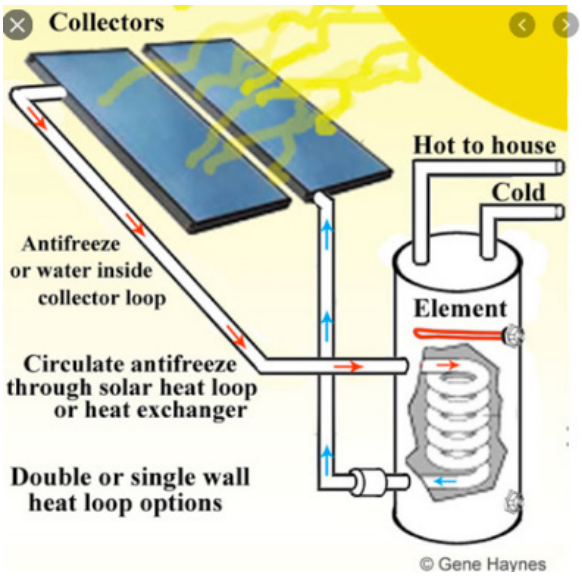
b. On-demand water heaters

c. Indirect water heaters



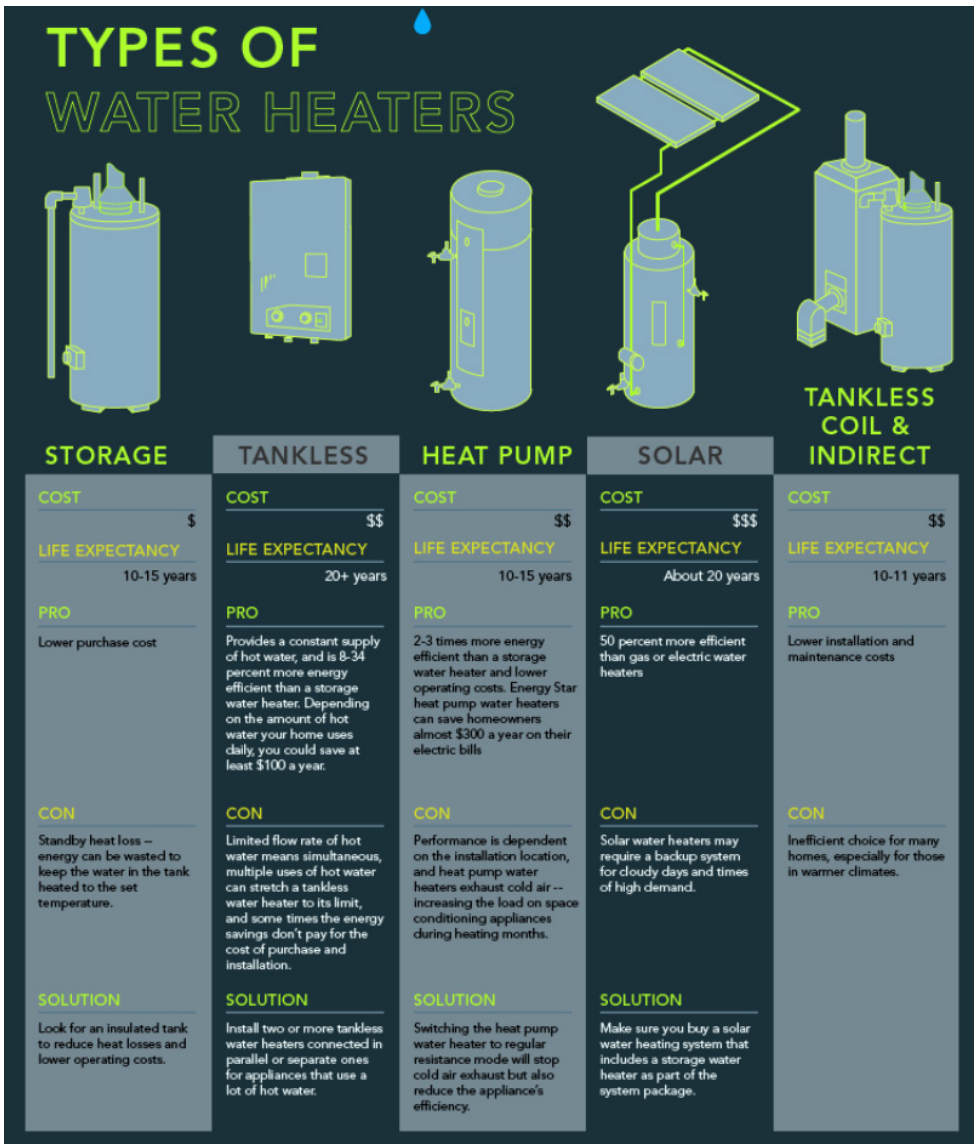


d. Solar water heaters

HOMEWORK

Design a Poster. Choose ***one*** of the ideas below and design a poster. You may use internet searches to help you locate additional information about your choice. Examples below.

1. Present a visual about one or more ways to save hot water use in homes.
2. Choose two kinds of hot water heaters and design a poster that compares the two and promotes your favorite.



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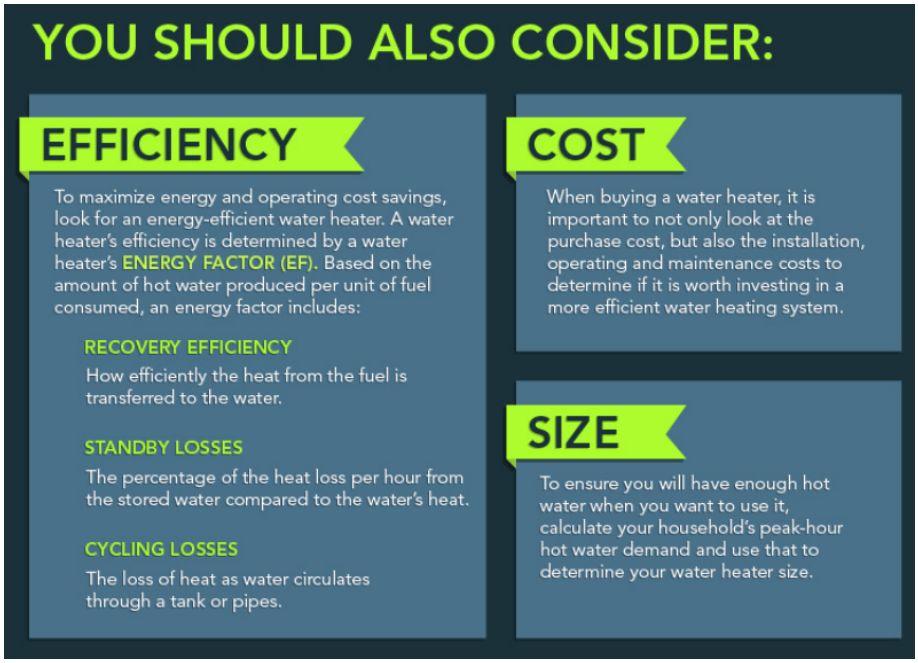
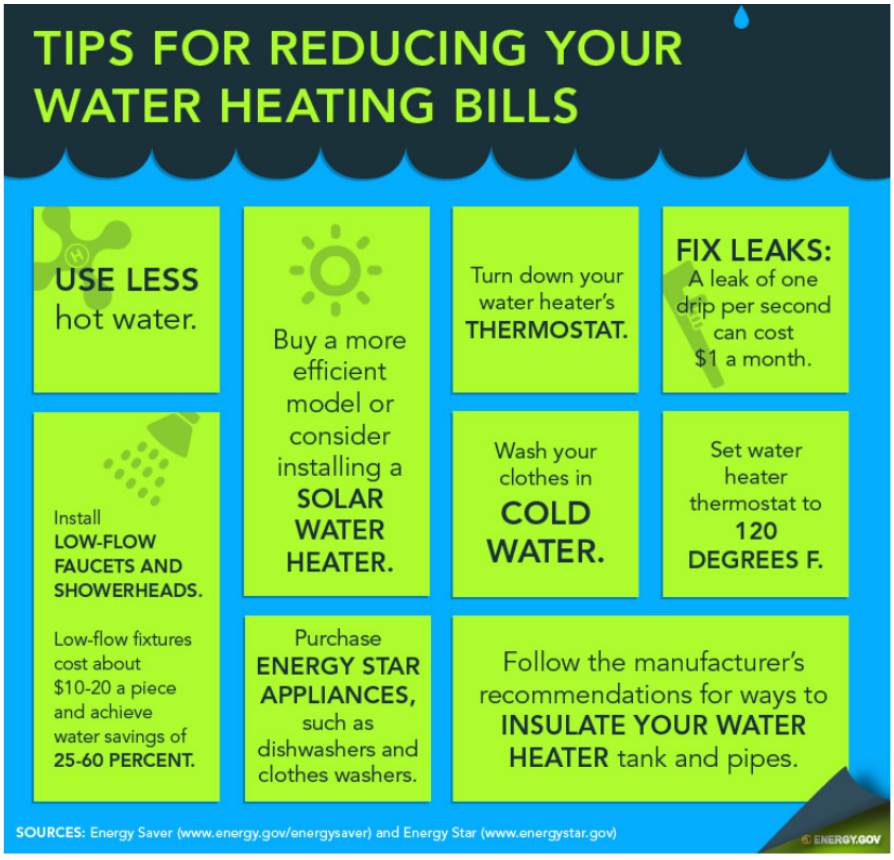
HOMEWORK (CONTINUED)





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ASSESSMENT

Quiz 5 (*Energy Conservation Handbook,* p.175) - Domestic Hot Water

RESOURCES/LINKS

This Old House: Shows inside of an older tank

https://www.youtube.com/watch?v=9kjabzIcLRA

Department of Energy Infographic about water and related energy use:

https://www.energy.gov/articles/new-infographic-and-projects-keep-your-energy-bills-out-hot-water

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Energy Efficiency

90 MINUTES

LESSON

Building Codes

BIG IDEA(S)

Knowledge of building codes assures safe, structurally sound and energy efficient houses.

OBJECTIVES

Students will:

- Describe the importance for understanding and following codes
- Give examples of local and state code resources
- Describe examples of codes that relate specifically to retrofit installation and house auditing

TASK LIST SUBCATEGORY

313 Explain local ordinances or laws regarding safe transport of materials

404 Describe relevant codes and requirements for permitting and installation

710 Identify the purpose of the National Electrical Code (or any code related to retrofit work

711 Demonstrate how to use the National Electrical Code Book as a referencing guide (or any appropriate code reference like the 2018 Philadelphia Conservation Code)

810 Use energy efficiency industry vocabulary

812 Use appropriate computer technology skills to conduct energy audits and design weatherization plans

OVERVIEW

Installers need to know codes and regulations. Regulatory organizations and codes are numerous and exist at the local, state, national and international levels. Their purpose is to provide installers, builders, architects with rules that assure safe, structurally sound and energy efficient houses. In Philadelphia, the Department of Licenses and Inspections represents the local agency for city government that is responsible for code compliance. Pennsylvania has codes that are provided from a variety of agencies. The local and state codes are often based on widely accepted standards at the national and international level. Discussion of the importance of code and standards is an important concept for Year 1 students.

STANDARDS

PA/SDP

3.4.10.B2. Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.

Construction Career Pathway (AC-CST)

- Describe the approval procedures required for successful completion of a construction project.
- Implement testing and inspection procedures to ensure successful completion of a construction project.

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WEATHERIZATION

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Auditing

90 MINUTES

KEY TERMS

See headings and list of organizations presented in the text.

STANDARDS (CONTINUED)

NGSS

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook, pp. 31-35

MATERIALS NEEDED

Content: Printed Philadelphia Licenses and Inspection weatherization checklist (see supplemental resource); on-line examples of International, national, state and local codes

Techonology: Computer with internet access

IMPLEMENTATION (LESSON PLAN)

1. Introduce the concept of codes: *Codes are like rules. Why is it important to establish rules for work or a game? Why do we have rules in basketball for instance? What happens when rules are broken? What are some examples of people who don't follow the rules?* (Move to the idea of standards, safety, organization, lack of confusion, working together, etc.)
2. Use the categories presented in the text to describe how codes work and are beneficial.
3. Describe examples of organizations that provide codes important to solar and weatherization work at the national, state and local level.
4. Apply the attached checklist to the Dense Pack Insulation Lab (*Energy Conservation Handbook* , pp. 137-142) and identify items that apply to this work.

RESOURCES/LINKS

UpCodes. Philadelphia Energy Conservation Code 2018 (IECC 2018)

https://up.codes/viewer/philadelphia/iecc-2018

This link connects to Philadelphia's code system and references local, state and international codes. It might be helpful to choose one aspect of the codes mentioned in the text for first year students to see one example explored live, such as Thermal Envelope. Scroll down to R402.4.1.1 Installation and check our Air Barrier and Insulation Installation, for example.

Pennsylvania Building Codes (2015)

https://up.codes/viewer/pennsylvania/iebc-2015

Philadelphia Department of Licenses and Inspections, Energy Compliance Materials (checklist in supplemental resources for ease of print out or display).

https://www.phila.gov/documents/energy-compliance-materials/

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TOPIC OF STUDY

Auditing

90 MINUTES

LESSON

Balloon and Platform Framing

BIG IDEA(S)

The framing of the house is an important variable when managing air flow/air leakage.

OBJECTIVES

Students will:

- Describe the house framing methods in order to understand air leakage, insulation needs
- Use a model to explain how the frame of the house is built
- Describe how problems develop due to moisture

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Building Sciences

90 MINUTES

TASK LIST SUBCATEGORY

802 Describe the interconnection of systems using the "House as a System" framework

803 Identify and evaluate mechanical, electrical, plumbing and roofing systems

804 Identify infiltration and exfiltration points

810 Use energy efficiency industry vocabulary

OVERVIEW

House systems are interdependent. Change one and that affects other parts. The frame of the house is hidden, but is important to consider for air leakage. The frames, or bones of the house, are mostly made of wood such as columns, beams, joists, rafters, all making up the structural frame.

KEY TERMS

exterior wall finish
platform framing
balloon framing
structural insulated panel (SIP)
R-value
vapor barrier
vapor retarder

STANDARDS

PA/SDP

3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.

3.4.10.E7. Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.

Construction Career Pathway (AC-CST):

(7) Compare and contrast the building systems and components required for a construction project.

NGSS

3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.

DEFINITIONS OF KEY TERMS

Exterior wall finish: layer of material attached to the outside sheathing, used for air and moisture control and visual appeal

Platform framing: floor joists rest on a will plate or on top of a stud wall

DEFINITIONS OF KEY TERMS (CONTINUED)

Balloon framing: typical method of house framing used prior to 1940. Their flaw is that air can travel from basement to ceiling easily

Structural insulated panel (SIP): prefabricated used for building walls and roofs, are insulation and framing in one piece

R-value: rating of materials to resist heat transmission

Vapor barrier: any material that allows zero moisture through

Vapor retarder: material that slows the diffusion of water vapor through it

BRIGHT SOLAR FUTURES

WEATHERIZATION

TOPIC OF STUDY

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90 MINUTES

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook, pp. 92-96

MATERIALS NEEDED

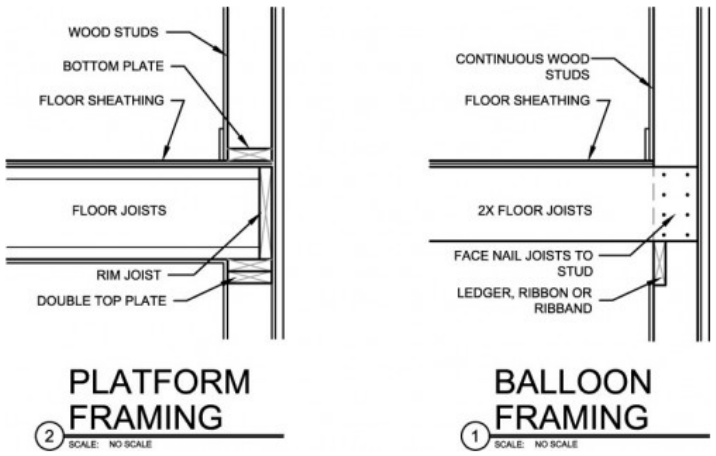
MATERIALS

- Scale model of a house with framing and systems, if available
- Actual portions of a framed house, if available in the lab

Technology: Computer with internet access

IMPLEMENTATION (LESSON PLAN)

1. Framing. If a miniature house with a see-through exterior is available, use this to discuss how a house is put together and how the systems all work together as one house system.
2. Platform Framing. This is the most common form of wood framing today. In this situation floor joists will rest on a sill plate or on top of a stud wall. The next level of wall framing will then sit on top of the fully sheathed floor joists. This method provides a built in fire stop and also creates a platform on which to construct the upper level wall. Balloon framing does neither of these. Refer to drawing two (2) on the right. Platform framing is presented on p. 93 in the *Energy Conservation Handbook*.
3. Balloon Framing. This method of framing was fairly popular on the east coast and parts of the Midwest in the past. Today it is not generally allowed by current building codes. However, it is good to be aware of the method in the event that it is encountered in the field.
    a. In this type of framing the wall stud rests on the sill plate with a rim joist in the interior side and then the floor joist. The stud wall is continuous from the sill plate to the top plate. At the second level the floor connection, joists rest on a ledger and are then face nailed to the studs. Refer to drawing one (1) on the right.

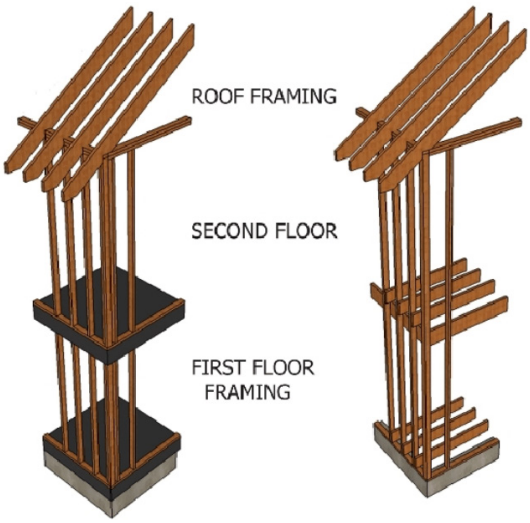


Balloon and Platform Framing

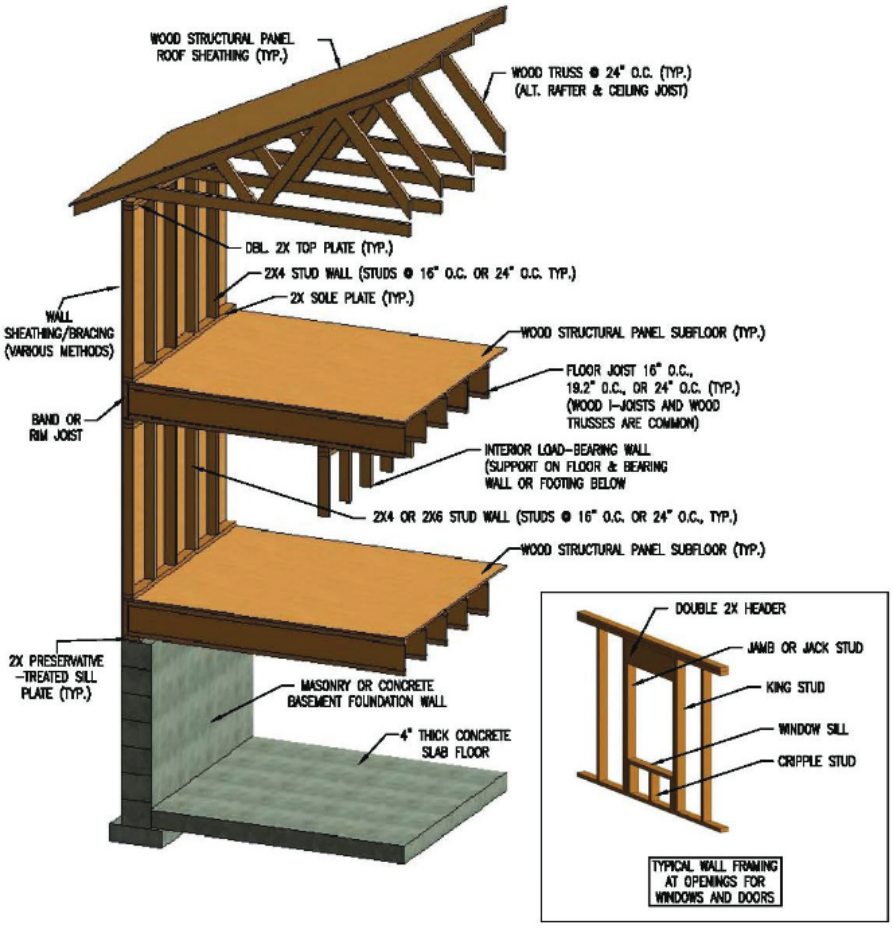
IMPLEMENTATION (LESSON PLAN) - CONTINUED

4. Comparing the two types.

   The following view allows students to see how each framing method with a larger view of the frame.



Close up of common framing elements for a platform frame:



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IMPLEMENTATION (LESSON PLAN) - CONTINUED

5. Review past lessons on moisture problems, infiltration, exfiltration and how house framing is part of these issues and systems.
6. **Quiz:** Building Construction (*Energy Conservation Handbook*, pp. 167-168). Provide practice by giving students the diagram to study before asking them to fill in.

RESOURCES/LINKS

Platform, Balloon and Advanced Framing Methods. Advanced presented in Year 2.

https://evstudio.com/three-wood-framing-methods-balloon-platform-advanced/

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