High-Performance Buildings

Teacher Manual: Lesson 4

Essential Question ("the Big Question")

How can we use different materials, designs, and processes to ensure that new buildings are part of our climate solutions?

Learning objectives. Students will be able to

1. Explain the importance of energy-efficient building design, construction, and materials and their role in fighting climate change
2. Identify examples of climate-critical professionals designing and implementing solutions for new buildings to contribute to our net-zero goals
3. Describe some characteristics of LEED-certified and Passive House buildings and how they differ from most current buildings.

Lesson Summary

High-performance buildings are an essential solution in our fight against climate change. When designed with sustainable materials, energy-efficient systems, and on-site power generation, such as solar arrays, buildings significantly reduce emissions over their lifetimes. Certification programs, such as LEED and Passive House, inspire developers and designers and ensure that minimum, essential building performance standards are met. The requirements surrounding high-performance buildings create a demand for a wide array of specialized careers and job opportunities in Massachusetts.

Technology referenced in this lesson: High-performance building design

Careers referenced in this lesson:

- Architects and designers
- Engineers
- Building contractors
- Equipment operators

- Carpenters, electricians, and plumbers
- Roofers
- Insulators
- HVAC contractors
- Building automation contractors
- Building inspectors

Agenda	Timing	PPT slides
Overview and Opening Activity	5 minutes	4
Present agenda and learning objectives	5 minutes	5–7
Direct Instruction Video Technology introduced Careers introduced	20 minutes	8–13
Primary Learning Activity Partner or small group work Reinforce what was learned	20 minutes	14–15
Closing Review learning objectives Closing activity Reflection	5 minutes	16–18
Extension		
Handouts - Group activity		
Total time	**55 minutes**	

Pre-lesson

preparation:

- Read the Student Presentation Deck (PPT).
- Watch the video(s) included in the Student Presentation Deck (most are available on the MassCEC YouTube channel).
- Print out the worksheets and handouts before class.
- Verify that the computer hosting the presentation deck is connected to the internet for video and hyperlink viewing.
- Check any links in the slide deck to ensure they work as intended, then review the content below.

Where to Learn More About This Lesson's Content

If extra preparation time is available, these resources will provide further background on the topics covered in this lesson:

- US Green Building Council: LEED Rating System
  LEED (Leadership in Energy and Environmental Design) certification provides a framework for healthy, highly efficient, and cost-saving green buildings that offer environmental, social, and governance benefits.
- MassCEC: High-Performance Buildings
  This website section details how MassCEC accelerates the decarbonization of the buildings sector by supporting the most impactful, resilient, and cost-effective electrification technologies and approaches.

Overview and Opening Activity (10 mins)

Materials and resources:

- Slide deck
- Student worksheets

Opening activity: Get students thinking and talking right away.

Activity objective: Working in pairs and based on knowledge gained in previous lessons, students will develop a theoretical answer to a complex building performance question.

Instructions:

- Divide the students into pairs or ask them to find a partner.
- They will have two minutes to discuss this prompt: *What do you think uses more energy—heating or cooling a building?* They should weigh their answers using anything they've learned about energy efficiency so far in this class.
- After two or three minutes, bring their attention back to the whole class for a group debrief:
  - Call on pairs to share whether they have reached a consensus.
  - Ask the students to raise their hands if they think it takes more energy to heat a building.
  - Then, ask the students to raise their hands if they believe it takes more energy to cool a building.
- This is a trick question since many factors go into determining the answer, including where the building is located.

Transition: Today, we will talk about the challenges of making buildings more energy efficient and some of the materials and strategies that create high-powered buildings of all kinds.

Present the Agenda

Students should familiarize themselves with the format: After the opening activity, they will learn new information. The main activity is intended to put them in the role of a building designer tasked with accommodating specific climate conditions. The closing activity provides an opportunity to suggest an improvement to their building's design and to speculate on a career role related to high-performance buildings.

Present the big question and the lesson objectives (see top of page 1):

- Ask the students for one example of a building material or building design approach that helps improve energy efficiency.
- Today, we'll explore strategies and technologies that make buildings more sustainable and energy efficient.

Key points to emphasize:

- Highlight Massachusetts as a leader in high-performance building materials.
- Share the example of The Offices at Winthrop Center in downtown Boston, which is the largest Passive House office building in the world, in addition to its LEED Platinum certification.

Possible discussion questions:

- How does the geographic location of Massachusetts influence the design of its high-performance buildings?
- Are there other ways that geographical location might influence the design of high-performance buildings?

Direct Instruction (20 mins)

Provide information to help the students achieve the learning objectives and prepare them to engage with the activity actively.

- Use inquiry-based learning strategies to engage the students when possible.
- Highlight careers related to the technologies.
- Help the students to relate the learning to themselves and their communities.

Show the video *TBD* (3–5 mins), followed by a brief check-in to hear what students took away.

Video debrief:

- What are some examples of Passive House design elements shown in the video?
- How would you describe the goal of Passive House design for energy efficiency?
- What did you learn from this video? What does this video make you want to learn more about?

Climate Watch Discussion

Discussion guidance:

- What are some of the benefits of high-performance buildings?
- What are the five principles of Passive House design?
- Why are buildings that are built to higher design standards healthier for occupants?

Key points to emphasize:

- Describe the principal benefits of high-performance buildings, such as those built to Passive House standards:
    - Lower energy usage, therefore fewer or no emissions contributing to climate change
    - Improved indoor air quality and increased occupant health and comfort
- Itemize the five principles of Passive House design
    - Balanced ventilation
    - High-performance windows and doors
    - High-performance mechanical systems
    - Super insulation
    - Passive orientation
- Accentuate that buildings built to higher design standards have better indoor air quality. This is because there are no combustion appliances (gas stoves, gas/oil burners), and they have the right ventilation to bring in and filter fresh air throughout the year.

Possible discussion questions:

- Can you name some careers that are essential to developing high-performance buildings that are climate solutions?
- What types of training and education may be required for careers related to high-performance building design and construction?

More than a Building

Discussion guidance:

- High-performance buildings use less energy and can even generate their own energy! Here are some key features of high-performance buildings (the slide details eight features).

Key points to emphasize:

- **Landscape and site design.** A well-designed surrounding landscape that uses shade trees and thoughtful building placement on the site reduces energy requirements.
- **Passive solar design.** Using the building orientation or overhang design, create energy-efficient structures.
- **Insulation and building envelope.** A tightly sealed, well-insulated, and well-built building envelope reduces energy needs.
- **Heating, ventilation, and air conditioning (HVAC) systems.** High-efficiency, electric HVAC systems save energy and can be powered by renewable electricity.
- **Smart building technology.** Programmable thermostats, smart lighting, and energy monitoring systems help optimize energy use.
- **Water efficiency.** Fixtures that reduce water usage, such as low-flow toilets and showerheads, reduce water use in homes and commercial buildings.
- **Renewable energy integration.** Clean energy sources like solar can meet a building's energy needs and reduce dependence on fossil fuels.

Possible discussion questions:

- Which of these features are you familiar with?
- Who has seen some of these features in their homes? What about here at school?

Certifications

Discussion guidance:

- Certifications can be necessary for establishing and maintaining standards for reducing emissions. This is especially significant as states, cities, and even countries worldwide set ambitious goals to lower emissions, creating a global movement toward greater energy efficiency.
- These certifications help ensure that the same efficiency standard is met and those goals are achieved.

Key points to emphasize:

- There are two main types of certifications for high-performance buildings:
    - **LEED certification** recognizes buildings designed and constructed to be **environmentally friendly and sustainable**. It considers factors such as energy efficiency, water usage, and materials to promote eco-friendly practices. Its primary focus is on sustainability.
    - **Passive House** is a design standard that **minimizes the energy required** for heating, cooling, and lighting. It focuses on design, siting, materials, insulation, airtightness, and ventilation to create efficient and healthy buildings.

Possible discussion questions:

- Do you know of other Massachusetts schools working to lower their climate impacts?
- What changes could make a difference in the emissions produced by and for this school?

Primary Learning Activity (20 mins)

Materials:

- Slide deck and slides
- Student worksheets

Activity Objective: Invite students to apply what they've learned about high-performance buildings and the unique properties of green building materials to the needs of different climates and introduce some of the skills necessary for designing climate-appropriate high-performance buildings.

Activity explanation: In groups, students will have ten minutes to design a high-performance building for their assigned climate using the information provided on their worksheets and what they've learned today. Students are encouraged to think outside the box and be creative! After ten minutes, each group will present their building to the rest of the class.

Instructions:

- Divide students into four groups and assign each group one of the four climates on the slides and worksheet: Cold, Desert, Tropical, or Coastal. Depending on the number of students in the class, you may divide students into smaller groups and assign multiple groups to the same climate to keep groups to four or fewer students.
- Working together, groups should do the following:
    - Review the environmental demands and challenges their climates present for energy-efficient buildings, as detailed on their worksheets.
    - Think about what challenges buildings face in different climates. What makes a building energy efficient in a cold climate versus a hot or coastal climate?
    - Identify materials and technologies they would use in their buildings to make them as energy efficient as possible **for their assigned climate**. For example, buildings in cold climates need to retain heat, while buildings in warmer climates require ways to stay cool.
    - Focus on three features they want to include in their building. Features should focus on saving energy and reducing emissions.

- Prepare to explain how each feature helps their building save energy and why it's appropriate for their climate.
- Sketch or design their building and its features (as time allows).

Presentations/debrief discussion:

- Invite each student group to share the highlights of their design, focusing on these three questions:
  - What challenges did they need to address in their climate?
  - What three energy-efficient features did they include in their design?
  - How do these features contribute to a high-performance design?
- After all the students have presented, and if time allows, ask one or two students
  - What did you learn about designing buildings for different climates?
  - What was the biggest challenge about designing a building for your climate?

Key point to emphasize: Adapting buildings to different climates is essential for reducing emissions and improving energy efficiency worldwide. Clean energy and energy-efficient technologies are not a one-size-fits-all solution.

Summarize key takeaways:

1. High-performance buildings are designed to use less energy, improve comfort, and reduce environmental impact.
2. Key features include energy efficiency, renewable energy integration, and smart technologies.
3. Equitable design ensures benefits for all communities, including disadvantaged ones.

Differentiations and Adaptations: Learning Activity (if available)

For students who benefit from visual aids, provide predesigned templates.
Adaptation: Offer building design templates or worksheets with labeled sections (e.g., walls, windows, roof, HVAC system). Include visual examples of high-performance building features such as insulation, solar panels, and energy-efficient windows tailored to different climates (e.g., desert, coastal, or cold).
Goal: To support students who may struggle with starting from scratch by giving them a clear framework to build upon, while still allowing room for creativity.

For students who prefer hands-on activities, use physical models or building blocks.

Adaptation: Provide small-scale model kits or building blocks for students to physically construct their high-performance building. Include materials such as transparent sheets for windows, foam for insulation, and small solar panel replicas to represent energy-efficient features.
Goal: To engage students who focus better with tactile activities by allowing them to build tangible models of their designs, making the abstract concepts more concrete and accessible.

Closing Activity (5 mins)

Materials:

- Presentation/slide deck, slides
- Reflection journal, student worksheets

Activity objective: To encourage students to apply and extend what they took away from the group activity.

Ask students to respond to these two prompts:

- If you had more time, would you change or add anything to your green building design?
- What role do you see yourself playing in creating energy-efficient buildings?

Discussion notes:

- Go around the room and ask students to answer these questions. They can answer aloud or write their answers in their journals or worksheets.
- They might have no professional interest in this type of work for the second question. They might want to own an energy-efficient home or ensure their workplaces use green energy sources.

Instructional steps:

1. Review the learning objectives so that students can summarize what they have learned.
2. Present the closing activity.
3. Allow time for reflection in their career journals.

Extension – If the students are loving this topic and want more . . .

Explore a real-world high-performance building.
Prompt: Research a well-known high-performance or net-zero energy building (e.g., Atlantic Wharf in Boston or Saugus Middle School). Create a short presentation explaining its features, how it adapts to its climate, and its impact on energy use and sustainability.
Goal: To encourage students to connect classroom concepts to real-world applications and learn about cutting-edge architecture and technology.

Design a building for extreme weather resilience.
Prompt: Choose an extreme weather event (e.g., hurricane, wildfire, or flood) and design a high-performance building specifically tailored to withstand it. Include features such as reinforced materials, water collection systems, or fire-resistant insulation. Create a labeled sketch or description of your design and explain how it protects against extreme conditions.
Goal: To push students to think critically about how high-performance buildings can address both energy efficiency and climate resilience.

Handouts – Group Activity (below)

Designing for the Climate

Instructions

Read the specific details for your assigned climate below. Then, follow the prompts on the next page to design your energy-efficient building.

Climates

Cold Climate

Key challenges:

- Extremely low temperatures with large amounts of snow and ice.
- High energy demands for heating.
- Long winters with short days mean fewer hours of sunlight for much of the year.

Desert Climate

Key challenges:

- High daytime temperatures and cold nights.
- Little rainfall requires ways to collect and conserve water.
- Intense sunlight and low humidity.

Tropical Climate

Key challenges:

- High humidity and warm temperatures year-round.
- Heavy rainfall may require sloped roofs or a drainage system.
- The risk of mold, mildew, and overheating requires good ventilation .

Coastal Climate

Key challenges:

- High winds, saltwater exposure, and occasional hurricanes and storms.
- Humidity and flooding risk requires waterproofing.
- The risk of flood damage may require an elevated foundation.

Design Prompts

Use the prompts below to design your energy-efficient, high-performance building for the assigned climate.

What is your assigned climate?

What materials will you use?

What three energy-saving features will your building include?
How will each help make your building high performance and energy efficient?

Sketch your design for the building below: