Spotlight: Electricians

Teacher Manual: Lesson 11

Essential Question

How do electricians play a critical role in implementing climate solutions?

Learning Objectives. Students will be able to:

1. Explore the range of clean energy projects that electricians work on
2. Identify the skills, training, and experiences needed to become an electrician
3. Discuss what aspects of a career as an electrician are aligned with their skills, interests, and desired work environment.

Lesson Summary

This is the first of seven lessons to highlight specific climate-critical in-demand careers. The lesson highlights how electricians reduce carbon emissions and support climate resilience in clean energy industries such as solar, wind, and residential and commercial energy efficiency improvements.

Other career-specific lessons include:

12. Engineers
13. Lineworkers
14. Managers and analysts
15. Construction, installation, and maintenance workers
16. Wind turbine technicians
17. Sales and customer service workers

Technology referenced in this lesson

- Solar
- Wind
- HVAC
- Building electrification
- Transportation electrification

Careers referenced in this lesson:

- Solar panel installer
- EV charger installer
- Wind turbine technician
- Residential and commercial electrician

Agenda	Timing	PPT Slide	
Opening Activity	5 minutes	2–5	**Pre-lesson**
Present agenda and learning objectives	5 minutes	6–8	
Direct Instruction Video Technology introduced Careers introduced	20 minutes	9–19	
Primary Learning Activity Partner or small group work Reinforce what was learned	20 minutes	20	
Closing Review learning objectives Closing activity Reflection	5 minutes	21–23	
Extension			
Handouts			
TOTAL TIME	**55 mins**		

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 worksheets before class.
- Verify that the computer hosting the presentation deck is connected to the internet for video and hyperlink viewing.
- Please check any links in the slide deck to ensure they work as intended, then review the content below.

Where to learn more about the lesson's content

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

1. Massachusetts Clean Energy Workforce Needs Assessment. The report describes the most in-demand jobs for reaching MA 2025 and 2030 climate goals.
2. JATC. Directory of Joint Apprenticeship Training Centers in Massachusetts
3. BLS occupational outlook for electricians

Overview and Opening Activity (10 mins)

Materials and Resources

- Slide Deck

Opening Activity: Get students thinking and talking right away.

Activity Objective: Let students learn about several tools of the trade. Electricians have some fun gadgets, so let's look at some of them!

Show the slide, and DO NOT CLICK to show the text so that students only see the image.

Background: Today's lesson is about electricians. Before getting into the details of what they do, this is a chance to see if students can recognize some of the essential tools in their toolkit.

Instructions

- Show the image on screen one at a time. Do not click a second time to reveal the answer until you are ready to do so.
- Invite students to call out if they know what this image is and what they think it's used for. Encourage students to apply what they have learned and use their imaginations.
- After a few guesses, click a second time to reveal the answer.

Tools

- **Multimeter** (pronounced muhl-TI-muh-ter): This is a tool electricians use to measure electrical properties. It is used to diagnose electrical issues and confirm that circuits function correctly.
- **Wire strippers:** These are not just pliers, but specifically wire strippers or wire stripping pliers. Electricians use them to remove the insulation coating wires without cutting the wire. Wires must be exposed carefully to make secure electrical connections, so these are essential.
- **Conduit bender:** Electricians often need to bend pipes or tubing to house electrical wires, and this is what they use to do that. Those tubes and pipes are called conduits,

and they enable electricians to ensure that the electrical wires running through a building are traveling through safe areas and won't be exposed to water, fire, or anything else that would be unsafe.
- **Circuit tester**: Electricians use this to see if any electrical current is running through an outlet or a circuit. This lets them know that a circuit is safe for them to work on, and it will let them know afterward that the power has been restored and the current is running through a circuit again.

Present the Agenda. Students should be getting familiar with the format:
- After the opening activity, they will learn new information.
- Students will learn more about *some* of the roles, skills, and career pathways for electricians—as electricians do so many things, this will not be a complete list!

Present the Big Question and Lesson Objectives
- How do electricians play a critical role in implementing climate solutions?
- Explore the range of clean energy projects that electricians work on.
- Identify the skills, training, and experience needed to become an electrician.
- Discuss what aspects of a career as an electrician are aligned with your skills, interests, and desired work environment.

Direct Instruction (20 mins)

Provide information to help the students achieve the learning objectives and prepare them to engage with the activity.
- Use inquiry-based learning strategies to engage learners where possible.
- Highlight careers related to the technologies.
- Help the learners to relate the learning to themselves and their communities.

Electricians in Clean Energy

Electricians install, maintain, and repair electrical power, communications, lighting, and control systems.

Invite students to call out how they think electricians contribute to each of these projects. Connect this back to the big question: reinforce that these projects are critical to reducing carbon emissions and meeting clean energy goals.
- Solar panel installation and maintenance
- EV charger installation
- Wind turbine maintenance

- Building electrification and upgrades
- Energy efficiency retrofits

Solar Energy

- There are three primary types of solar projects: residential, commercial, and utility scale.
- Each project type differs in terms of scale and purpose.
- Ask: Why would it be essential to have electricians who know how to work on small and large solar installations?
    - Project needs differ widely based on the size and location of the project, the electrical load, and the age and capacity of the grid components.

Wind Energy

- There are also various types of wind energy projects, including offshore wind farms, utility-scale wind farms, and community wind projects.
- As with solar, each type varies in size, who it serves, and its overall purpose.
- Each may require different skills from an electrician, especially in terms of the scale of the project or how it's connected to the grid.
- For example, offshore and utility-scale projects are large and complex, while community projects are usually smaller and locally managed.

Building Electrification

- Electrification of any building helps to replace fossil fuel-based systems with electric systems, which reduces emissions and makes buildings more energy efficient.
- These projects, whether part of building new construction, updating specific systems, or retrofitting whole buildings, all require electricians and their expertise.

Transportation Electrification

- Transitioning to EVs requires electricians to install and maintain a charging station network, whether for personal vehicles or public transportation.
- This includes charging stations people want in their homes or garages, charging stations owned by multifamily buildings or businesses, and charging stations in public spaces.
- Projects like these, installed and operated in public areas, often have additional safety risks and precautions.
- Specific steps are needed to keep the site and materials safe while installation is in progress, and precautions are taken to ensure that the site remains secure, as it could be accessed or used by just about anyone.

Show the video (three to five minutes) and follow it with a brief check-in to hear what students took away.

Video Debrief

- What did the apprentices say that they liked about beginning their career path with an apprenticeship?
- What is one question you would ask an apprentice?
- What do the apprentices highlight as benefits of training through the IBEW trade union?

Clean Energy Workers' Trade Unions

- Electricians are one of the clean energy career paths that have a union. Many licensed trades, like electricians, pipefitters, plumbers, utility workers, carpenters, and others, can join unions. These are some of the unions that are common for trades and careers in clean energy (not a complete list):
    - For Electricians: International Brotherhood of Electrical Workers
    - HVAC: Sheet Metal Workers International Association
    - Weatherization: International Association of Heat and Frost Insulators and Asbestos Workers
    - Water heating and geothermal workers: United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry
    - International Union of Painters and Allied Trades
    - Solar Technicians: Laborers International Union
- The video shows that unions provide many worker benefits, including apprenticeships and training programs.
    - For many, unions make it possible to achieve stable, high-paying jobs without taking on college debt and—as seen in the video—even earning money while training.
    - Many unions offer extensive training opportunities across Massachusetts and the country.
- Many unions help establish what are known as prevailing wages across the state.
    - Prevailing wage law in MA ensures that workers on public construction projects, such as building schools or roads, are paid fairly.
    - The "prevailing wage" is the state's standard pay rate for different jobs. It ensures workers earn good wages and fair competition between companies.

Wages and Demographics

- Point out the wages at the top of the graphic, specifically the median wages for electricians in Massachusetts.
- However, the prevailing base hourly wage for Electricians working in the Boston area is closer to $60/hour.
- Electricians can earn higher wages with additional specialized training and experience.
- Point out that 83 percent of electricians do not have a bachelor's degree, so this is a career path that doesn't require a four-year college education.
- This data is from the Massachusetts Clean Energy Workforce Needs Assessment.

Knowledge and Skills

Electricians are highly skilled technical experts with an essential skill set and knowledge base. For example:

- **Installation of electrical equipment**: Experience installing various electrical components, such as circuit breakers, transformers, outlets, switches, and lighting systems. Proficiency in setting up electrical panels and subpanels.
- **Maintenance and repair**: Skills in maintaining and repairing existing electrical systems, ensuring they operate efficiently and safely—the ability to replace faulty components and perform regular inspections.
- **High-voltage work**: Knowledge and skills to work with high-voltage systems, including safety protocols and specialized equipment.
- **Energy management systems**: Understanding energy management and efficiency practices, including installing and maintaining energy-efficient lighting and HVAC systems.

Electrician Knowledge and Skills

Review the types of knowledge and skills required. What do students notice about them?

- You must want to learn about electricity and circuits and how they work.

Training Pathways

- Electricians must be licensed in each state where they work.
- According to the Massachusetts State Board of Examiners, before you take the Journeyman's State Licensing Exam, you must complete:
    - 8,000 hours of employment (approximately four years) as an apprentice under the direct supervision of a holder of an MA Class B Journeyman's License
    - 600 Hours of classroom instruction in electrical code and theory from an approved school based on the current National Electric Code.
- Vocational and technical schools can provide hands-on experience and technical knowledge specific to electrical work and renewable energy.

Primary Learning Activity (20 mins)

Materials

- Worksheets

Activity Objective: Simulate electricians' real-world planning for clean energy projects. Students will better understand electricians' essential role in making sustainable energy projects safe and effective.

Group assignment projects for this activity

1. Solar panel installation
2. EV charging station set up
3. Wind turbine maintenance
4. Energy efficiency retrofit

Instructions

- Divide students into groups; each group will work on a different project type (see above). If the class size allows for more than four groups, more than one group can work on each project plan. Direct students to their worksheets, which will guide them through the activity.
- As a group, students should examine the details of their assigned project provided on their worksheets. Then, students should consider the practical steps of completing their project and discuss the specific tools they need and unique safety measures.
    - For example, Group 1 would consider roof suitability; Groups 2 and 4 would consider the energy sources for their projects.
- Students will have 12 minutes to plan their projects and make short (one-minute) presentations to the class.

Debrief Discussion

- What did they learn about the planning involved for their project type?
- Did this activity change how any of them viewed or felt about electricians?
- Conclude by emphasizing that electricians are essential for the success and safety of clean energy projects and for Massachusetts to meet its clean energy targets.
- Touch on some of the specializations in electrical work that have come up in these projects, all of which contribute to climate resilience.

Summarize Key Takeaways:

1. Electricians will be needed in most clean energy industries discussed: HVAC, solar, wind, hydropower, and electric transportation.
2. Electricians work with their hands rather than at a desk.
3. Electricians can start their education in a technical school or as an apprentice.
4. Electrical apprenticeships are four to five years long.
5. You can begin an apprenticeship as young as 18.
6. Although an electrician does not require a college degree, a degree can be helpful if you want to start your own electrical contracting business.
7. Electricians are critical in implementing climate solutions because most solutions involve electric power.

Differentiations and Adaptations—Learning Activity

For students who benefit from hands-on engagement: use a physical model.
Adaptation: Provide simple materials to create a mock-up of an electrical component related to their project plan. For example, if a group's plan involves wiring a building, they can construct a small circuit to demonstrate part of their design.
Goal: Engage students who benefit from hands-on activities while giving all students a tangible way to visualize and explain their plan.

For students who struggle with verbal presentations: use visual storyboards.
Adaptation: Students can create a visual storyboard or poster outlining their project plan. Each worksheet step can be translated into a storyboard section with illustrations, diagrams, or key points. Groups can use this visual aid to guide their presentation.
Goal: Support students who may feel anxious about speaking by giving them a structured and creative way to convey their ideas visually.

Closing Activity (5 mins)

Materials

- Presentation/slide deck, slides
- Reflection journal

Activity Objective: Encourage students to reflect on key takeaways and identify areas of curiosity for further exploration.

Achieving net zero emissions heavily depends on electrification, meaning electricians are essential to achieving our climate goals.

Encourage students to respond to one or more of these questions to wrap up the class.

1. What challenges will we face if we don't have enough electricians for clean energy projects?
2. How can we encourage more people to enter the electrician field?
3. How do electricians help build climate resilience?

Check individual understanding of learning objectives.

Extensions—if learners are loving this topic and want more…

Explore Smart Electrical Systems
Prompt: Research how electricians install and maintain smart home systems that connect to the internet, such as programmable thermostats, smart lighting, or energy monitoring devices. Create a short presentation or visual display explaining one smart system, how it works, and how it supports energy efficiency.
Goal: Introduce students to advanced technologies electricians work with and their role in sustainable energy solutions.

Interview an Electrician or Watch a Virtual Tour
Prompt: Either interview a local electrician or find a day-in-the-life video of an electrician who works on clean energy projects. Write a reflection on what you learned about the profession, including the skills and tools they use and how their work supports clean energy initiatives.
Goal: Provide real-world context for the career, allowing students to connect classroom learning to professional experiences.

Handouts—Group Activity (below)

Electrician Project Planning Challenge

Instructions

Your team is responsible for planning an important project in your town as part of a local push for clean energy and electrification. Read the details of your assigned project on the following pages. Then, use the prompts below to identify your project's main goal and anticipated impact.

Project Planning Prompts

Key steps: What steps will your team need to take to complete your project?

What tools or resources will you need?

How will this project affect the community?

Briefly summarize your project plan:

Solar Panel Installation

Group 1

Objective: Install a 10-kilowatt (kW) rooftop solar panel system in the community center to reduce electricity costs and support clean energy goals. The building's current electrical system is over a decade old and not designed for renewable energy, so an assessment is required to determine if upgrades are needed.

Location: The project site is a two-story community center with a flat, rubber-coated roof. The building is connected to the city's power grid, but there are no current connections for renewable energy. A nearby electrical panel can connect to the solar inverters, but upgrades may be required to handle additional power safely.

Challenges:

Assessing power compatibility: The building's electrical panel may need upgrades to accommodate solar power, as the current setup may not be able to handle the additional load.

Grid connection: Safely connecting the solar system to the city grid requires specialized equipment, such as a solar inverter that manages power fluctuations.

Special tools and equipment: Electricians may need specialized tools, such as a solar inverter and a DC disconnect, to ensure safe integration with the grid.

Notes:

EV Charging Station Setup

Group 2

Objective: Plan and install an EV charging station with two charging ports at the high school parking lot to support staff, students, and the school's green initiatives. The school's current power system was not designed for high-energy chargers, so electricians must evaluate the feasibility of installation.

Location: This outdoor parking area is close to the school's main entrance, with nearby electrical lines that could be accessed for connection. The location is open and exposed to the elements, so waterproofing and protection from weather conditions are necessary. There is also moderate foot and vehicle traffic in this area.

Challenges:

Power demand: The chargers require a substantial amount of power, which may exceed the current system's capacity, necessitating an evaluation of load handling and possibly an upgrade to the electrical panel.

Weather protection: Outdoor installation requires weatherproofing, including weather-resistant enclosures and connections, to prevent water or dust damage.

Traffic management: Electricians must consider foot and vehicle traffic when choosing charger placement to ensure safety for users.

Specialized equipment: High-power charging requires specialized tools and heavy-duty circuit breakers for safe installation.

Notes:

Wind Turbine Maintenance

Group 3

Objective: Perform a comprehensive maintenance check on a 1.5-megawatt (MW) wind turbine located on a hill that supplies power to the local water treatment plant. Maintenance includes checking the turbine's electrical components for wear to ensure continued safety and efficiency.

Location: The wind turbine is situated on elevated terrain, exposed to high winds and fluctuating temperatures. Access is limited, as the turbine is located away from main roads, requiring a specialized team for safety and logistics. Power cables run from the turbine to the water treatment facility nearby.

Challenges:

Safety at height: The turbine requires safety harnesses and fall-protection gear for electricians working on the blades and nacelle.

Electrical check: High-voltage components, including the inverter and transformer, must be inspected for signs of wear and safe operation.

Access issues: The remote location requires special transportation of tools and equipment, making logistics a priority.

Weather conditions: The elevated site is subject to high winds, limiting safe working hours to periods of low wind.

Notes:

Energy-Efficiency Retrofit

Group 4

Objective: Plan an energy-efficient electrical retrofit for a 50-year-old, multi-story office building with outdated lighting, an HVAC system, and a lack of modern energy monitoring. The retrofit aims to reduce energy consumption and improve occupant comfort.

Location: The office building is downtown, with a high occupancy rate and limited opportunity for disruptive work. The current electrical system needs to be updated and may only support modern energy-efficient appliances with upgrades. There is restricted access to the main electrical panel, which is in the basement.

Challenges:

Limited electrical capacity: The building's existing panel may need to be replaced with a larger panel to handle the additional load from new lighting and HVAC systems.

Compatibility with older infrastructure: Integrating modern, energy-efficient systems with older infrastructure may pose challenges and require additional equipment or adapters.

Minimizing disruption: Electricians must plan to work during off-hours or in stages to avoid disturbing the building's occupants.

Compliance with updated codes: The building must meet current electrical and safety codes, which may require additional work and inspections.

Notes: