



Transforming Transportation

Teacher Manual: Lesson 8

Essential Question

How can electric vehicles support our transition away from fossil fuels?

Learning Objectives. Students will be able to:

1. Describe the benefits of electrifying transportation and explore solutions to some of the most significant barriers
2. Identify climate-critical professionals who work on electric vehicles and charging infrastructure
3. Discuss what communities need to electrify transportation fully.

Lesson Summary

Students examine two primary strategies to reduce pollution from the transportation sector: reducing growth in total vehicle miles traveled (VMT) by improving alternatives to personal vehicles and transitioning most vehicles on the road to electric vehicles. They are introduced to transit-oriented development and learn about the challenges to siting charging infrastructure.

Technology referenced in this lesson

- Electric vehicles
- Charging infrastructure

Careers referenced in this lesson:

- EV Technicians: Maintain and repair electric vehicles
- EV Charging Equipment Technicians: Install and service charging stations
- Engineers (Automotive and Chemical): Design vehicle systems and improve battery technology
- Car Salespeople: Educate customers on EV benefits and maintenance needs

Agenda	Timing	PPT Slide	Pre- lesson
Opening Activity	5 minutes	2	
Present Agenda & learning objectives	5 minutes	3-5	
Direct Instruction Video Technology introduced Careers introduced	20 minutes	6-15	
Primary Learning Activity Partner or small group work Reinforce what was learned	20 minutes	16-17	
Closing Review learning objectives Closing activity Reflection	5 minutes	18-20	
Extension			
Handouts			
TOTAL TIME	55 mins		

Preparation

- Read Student Presentation Deck (PPT)
- Watch video(s) included in 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.
- Check any links in the slide deck to make sure they work as intended, and then review the content below.

Where to learn more about the lesson's content

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

1. Day at Work: Electric Vehicle Technician (3-minute video from ConnectEd.
2. <https://youtu.be/M05oLsNnngY?si=w0LS2ypadA09qqbb>
3. Alternative Fuels Data Center. <https://afdc.energy.gov/>
4. How do all-electric vehicles work? <https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work>

5. Electric Busses (Cape Cod Technical HS, Franklin Park Zoo, etc.)
<https://www.mass.gov/news/massachusetts-school-districts-win-42-million-in-federal-funding-for-clean-school-buses>
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Overview and Opening Activity (10 mins)

Materials & Resources

- Slide Deck
- Student Worksheets

Opening Activity. Get students thinking and talking right away.

Activity Objective: Students think about the bigger picture of what influences wide scale change in society.

Instructions

- Students can do this activity in small groups, pairs, or as a class together.
- Ask students to consider all modes of vehicles and public transit and brainstorm and discuss: *What would need to change to make all cars and public transit electric?*
- Students should consider technological, social, and infrastructure-related barriers to transforming and adopting new technologies.
- After a couple of minutes, if students have been discussing in pairs or small groups, ask for a few students to share their suggestions with the class and highlight common themes.

Present the Agenda. Students should be gaining familiarity with the format:

- After the opening activity, they will learn new information. The main activity is intended to apply what they've learned. The closing activity helps them synthesize what they learned and transfer knowledge.

Present the Big Question and Lesson Objectives

- How can electric vehicles support our transition away from fossil fuels?
 - Describe the benefits of electrifying transportation and explore solutions to some of the most significant barriers.
 - Identify climate-critical professionals who work on electric vehicles and charging infrastructure.
 - Discuss what communities need to electrify transportation fully.
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Direct Instruction (20 mins)

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

MA Climate goals - Transportation

- Transportation is the largest source of GHG emissions in MA, responsible for 37% of statewide emissions in 2020. Pollution in the transportation sector is caused by the combustion of fossil fuels in the engines of cars, trucks, airplanes, and other vehicles. [source: 2025/2030 CECP pie chart p.7 of plan]
- Primary strategies to reduce pollution from the transportation sector include
 - reducing growth in total vehicle miles traveled (VMT) by improving alternatives to personal vehicles.
 - improve public transportation
 - build more housing and redesign our public space by encouraging transit-oriented development
 - improve and electrify bus service
 - Transitioning most vehicles on the road to electric vehicles

Transit-oriented development

Transit-oriented development is one of the major strategies Massachusetts will deploy to improve sustainable transportation.

- Transit-oriented development supports a cleaner environment by lowering emissions directly by decreasing the need for cars.
- People use fewer cars because they have easy access to public transit or because they are closer to offices, shops, and other necessary community centers, making these communities more bikeable and walkable than other areas.
- This type of development has other positive effects beyond the environmental impact, as it can help foster community connections in other ways, too.

EV in public transportation

Massachusetts's second major strategy for transforming transportation across the state is electrifying public transit. This includes buses, rail, and even school buses in some areas.

- Electric public transit options help reduce the state's overall carbon footprint.

- These changes have a significant impact on community health by lowering emissions and improving air quality which benefits everyone, especially in urban areas and around schools.
- Switching to electric public transit encourages residents to rely less on personal vehicles, contributing to reduced total vehicle miles traveled.

Why electrify transportation

- Electrifying transportation is essential for reducing emissions and improving public health because transportation is currently the state's largest source of carbon emissions.
- So, despite the challenges, it's worth the effort.

Benefits

- Electric vehicles can reduce pollution and improve overall quality of life, especially in high-traffic areas.
- Benefits include reduced air pollution since electric vehicles don't produce any tailpipe emissions.
- EVs are also much quieter than gas-powered cars, lowering noise pollution, especially in urban or densely populated areas
- Unlike traditional cars, they can be powered by renewable sources like wind, solar, or geothermal systems.
- Because they connect to the power grid, electric cars can store energy and feed it back to your home or even the grid for use later. This is becoming more common now and is a real benefit because it allows you to use your electric vehicle as a backup generator during a power outage.
- Imagine if cities could use electric buses or trains in this same way to feed power back to essential services like hospitals or fire stations.

Challenges and Barriers

- People will raise several challenges and barriers to adopting electric transportation, but these are four of the most common.
- Public resistance to changes like transit-oriented development could mean plans to build more housing closer to public transit to reduce the need for cars or develop new infrastructure that supports electric transportation.

- High costs of electric vehicles and charging infrastructure – There may be a high upfront cost, and for many people, hearing that it's cheaper in the long run isn't enough for them.
- Limited charging infrastructure, especially in rural and multifamily areas - If everyone starts using electric cars, do we have the capacity for all those folks to charge their cars? Do we have adequate charging stations? Does our grid have the capacity to charge that many vehicles? What about adding in public transit vehicles?
- Concerns about the convenience of finding chargers on long trips – Some charging stations are faster than others, but few are faster than filling up a tank with gas. So if people are driving for hours and hours, they don't necessarily want to wait around for their car to charge halfway through. This would also be relevant for folks like long-haul truckers or vehicles like buses that are expected to run continuously for certain amounts of time; needing additional time to charge has to be factored into schedules and routes.

Show the video (3-5 minutes) and follow it with a brief check-in to hear what students took away.

- **This video, A Day in the Life of an EV technician, is a placeholder for the MassCEC video being created for this curriculum.** You can skip this video and the debrief discussion questions if you wish.

Video Debrief (Day in the life of an EV technician)

1. In the video, Ben works on electric cars and bikes. How do electric bikes help urban centers transition away from fossil fuels?
2. Ben describes engineering and design as working together. How do these two types of work come together in clean energy?
3. What stood out to you most about this video and the idea of working in electric transportation?

Primary Learning Activity (20 mins)

Materials

- Worksheets

Activity Objective: Students must consider the factors that contribute to a desirable location for an EV charging hub. Groups will work to design EV charging networks to maximize accessibility and efficiency.

Instructions

- Divide students into groups and direct them to their worksheets containing the activity's maps, criteria, and budget information. Since all groups will be working from the same prompts, the teacher can choose the size of the groups.
- After examining the provided information, students will work in groups to design an EV charging network to maximize accessibility and efficiency for a fictional town. They must consider public concerns, budget constraints, existing infrastructure, and accessibility.
- Criteria:
 - Accessibility: proximity to bus/train lines and major roads
 - Public concerns: address potential pushback on development or disruption
 - Efficiency: think about traffic flow and high-demand areas
- Networks can consist of a combination of three types of charging stations:
 - Small (car only): low cost, minimal disruption, suitable for residential areas
 - Medium (car and bus): higher cost, longer installation time, best near transit hubs
 - Multi-use (car and bike): Moderate cost, appealing to urban users, suitable for business districts
- Students will design their system by following the prompts on their worksheets and prepare to present their plan to the “City Council” (the rest of the class). Their presentations should include:
 - How they will allocate funds to maximize the impact across the city
 - Why they believe their location choices to be the most beneficial
 - How they plan to handle potential concerns from residents or businesses
- Encourage students to share why their plan will encourage people to transition to using EVs while minimizing public resistance.

Debrief Discussion:

- After each group presents, facilitate a short discussion to compare plans
- Ask students to vote (as “city council” on which plan they want to move forward with for their town!

- Ask students what factors were most important to them when planning their designs?
What factors were most important when evaluating the designs?
- Designing an effective EV charging network involves careful consideration of community needs, financial constraints, and logistical challenges.
- Bringing EV infrastructure into any community is challenging, even if the community is supportive.

Summarize Key Takeaways:

1. Electric transportation helps reduce emissions, improve air quality, and support grid resilience.
2. Barriers include cost, infrastructure limitations, and public resistance to change.
3. Careers in EV technology are critical to achieving sustainable transportation.
4. It will take a collective effort to overcome common barriers.

Differentiations & Adaptations - Learning Activity

For students who benefit from visuals: Use Maps and Physical Models

Adaptation: Provide a large map of the fictional town and allow students to use markers, stickers, or small objects to place and visualize their EV charging stations. Alternatively, let students create a simple 3D model of their network design.

Goal: Engage students who benefit from hands-on activities and visual aids by making the design process more interactive and tangible.

For Students who struggle with public speaking: Offer alternate presentation options

Adaptation: Allow groups to record a short video or create a slide presentation with narration to present their EV charging network plan. Instead of delivering live, it can be played for the “city council.”

Goal: Reduce anxiety and ensure all students can fully participate in sharing their ideas, regardless of their comfort level with public speaking.

For students who require more guidance or structure: Provide Examples

Adaptation: Offer possible combinations of EV charging networks in similar towns. Include a simple map and a brief explanation of why specific locations were chosen for charging stations. For example:

- “In Town A, charging stations were placed near a shopping center, a school, and a major highway to maximize accessibility.”
- “In Town B, the focus was on underserved neighborhoods and areas with low existing infrastructure.”

Goal: Give students a clear starting point by showing how decisions might be made in similar situations. This helps those who need additional support understand the process and generate ideas for their own design.

Closing Activity (5 mins)

Materials

- Presentation/Slide Deck, slides
- Reflection journal or worksheets

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

Ask students to respond to these two questions:

1. If you could add one feature to EV vehicles to speed up public transition, what would it be and why?
2. What do you think is the greatest challenge of transit-oriented development projects?

Check individual understanding of Learning Objectives.

Extensions - If learners are loving this topic and want more ...

Create a Public Awareness Campaign for EV Adoption

Prompt: Design a public awareness campaign to encourage your fictional town's residents to switch to electric vehicles. Include a slogan, key benefits (e.g., cost savings, environmental impact), and strategies to address common concerns like charging access and upfront costs. Present your campaign as a poster, short video, or social media post series. Or, learn what EV transformations are happening in your town and create a campaign for your actual community!

Goal: Encourage students to think beyond infrastructure and consider the social and behavioral aspects of transitioning to electric vehicles.

Design a Multi-Modal Transportation Plan

Prompt: Expand your EV charging network design into a full multi-modal transportation plan for your town. Incorporate solutions like bike-sharing, public transit upgrades, or walkable pathways alongside EV infrastructure. Create a map or proposal showing how these systems work together to reduce emissions and improve mobility for all residents.

Goal: Challenge students to think holistically about transportation systems and explore solutions beyond electric vehicles.

Handouts - Group Activity (below)

EV Charging Network Design

Instructions

The City Planner has asked you to propose a new EV Charging Network for downtown in your small city. This network should be accessible and beneficial to residents and businesses and should help encourage the community to use more electric vehicles.

Below are the criteria and considerations for this proposal. On the following pages, you will find additional notes collected by the City Planner and a map of downtown.

Budget: \$100,000

Criteria for Ideal EV Charging Network:

- **Accessibility:** Stations should be close to heavily trafficked locations, such as transit hubs, business districts, and residential neighborhoods.
- **Public Support:** Minimize disruption to community spaces, avoid excessive inconvenience to businesses, and consider anticipated public resistance.
- **Efficiency:** Place stations in areas with the most need or expected demand to maximize the budget’s impact.

Charger Type	Cost	Use	Space Required	Install Time
Small: 2 ports per station	\$10,000	Car only	10' x 20'	1 month
Medium: 4 ports per station	\$25,000	Cars, e-bikes	20' x 30'	2 months
Large: 6 ports per station	\$45,000	Cars, Bus	30' x 40'	3 months

Notes:

The City Planner has shared the following notes with you about possible public concerns related to EV charging stations downtown:

Notes from the City Planner:

North Neighborhood Residents have high incomes and support clean energy, but they are concerned about the convenience of using EVs without home charging stations.

Downtown Business Owners worry that charging stations will take up too much space and make parking tricky for customers. They may oppose large installations unless clear benefits to foot traffic or customer satisfaction are shown.

The **School and Park Area** sees high foot traffic, especially before and after school. Residents in the South Neighborhood and students' families use the park frequently and would appreciate convenient charger access. Some residents are concerned about changes affecting green spaces.

Commuters at Train Stations rely on the train to travel to work and are interested in using EV charging facilities while they're at work. However, any installation would need to be coordinated with transit authorities.

The **Bus Depot and Transit Center** are frequently used by transit vehicles, and drivers may need charging options for future electric buses. Some unused space exists, but placing chargers here may lead to construction delays and minor transit disruptions.



Design Prompts

The City Planner has asked you to propose a new EV Charging Network for downtown in your small city. This network should be accessible and beneficial to residents and businesses and should help transition the community to use more electric vehicles. Prepare your plan using the prompts below.

How many of each type of charging station will you build?

What are the 1-2 most substantial benefits of this plan for the community?

What concerns do you anticipate from community members and how will you address them?

What factors were most important when designing your EV charging network? Why?