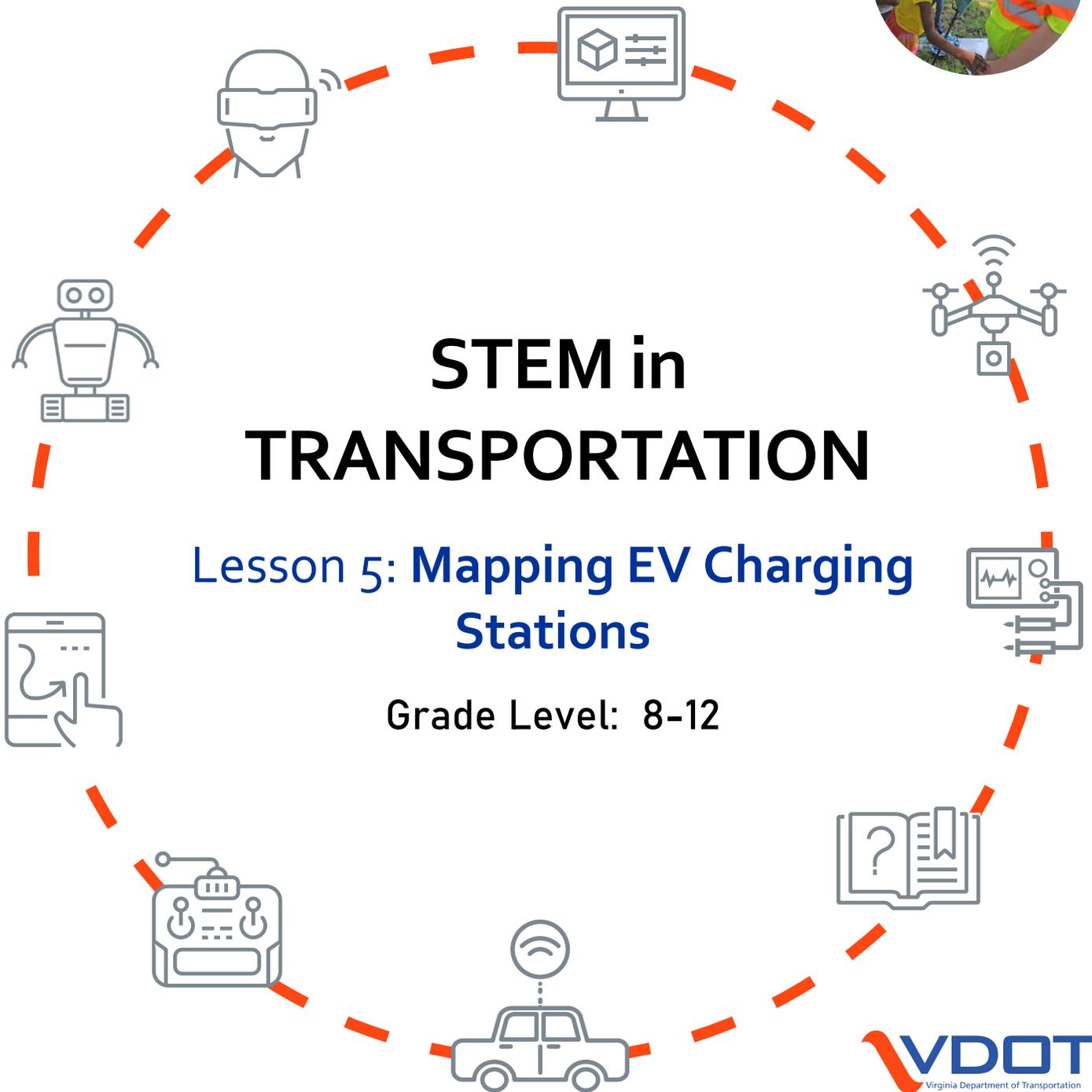




STEM FOR STUDENTS DRIVE IT HOME



Mapping EV Charging Stations

Background Knowledge

As society looks for ways to reduce its reliance on fossil fuels, electric vehicles have made a comeback and increasingly become more popular. There are barriers to adoption of this technology though. Long trips require frequent or long stops for vehicle charging unless there is easy access to a fast charger. Apps such as PlugShare have emerged to help owners locate places to charge their vehicles, but are there enough convenient charging stations to make owning an electric vehicle more efficient or at least not burdensome in the long run?

In addition to charging access while traveling, there may be other barriers to owning electric vehicles. Those who live in apartment complexes or who rent homes cannot simply install a charging station at their home. For these individuals, owning an electric vehicle may be a huge hassle unless their place of employment offered charging options.

In this lesson, students will explore the trends in electric vehicle ownership and adoption and some of the challenges for mass adoption of this technology.

Prior Skills & Understanding

Students will need to know how to read maps and analyze the information contained within them. They will also need to be able to make connections and draw conclusions from various sets of data and information sources.

Procedure

1. Have students investigate trends in electric vehicle production, purchasing, and government

STANDARDS OF LEARNING DE.22 – 23, CE.1

Objectives

Students will:

- Understand the current trends in electric vehicle ownership
- Understand the barriers that may hinder electric or alternative fuel vehicle adoption
- Know how to locate and interpret geographic information related to electric vehicle charging stations
- Use research information to forecast needs for additional charging station locations
- Present their findings and solutions to the class or other audience

Materials

- Internet access
- Presentation software
- Google Maps or ArcGIS

Time: 4 hours

incentives. A good start is the [Alternative Fuels Data Center: Electric Vehicle Charging Stations \(energy.gov\)](https://www.energy.gov/alternative-fuels-data-center).

2. Discuss the barriers to electric vehicle ownership (cost, availability, lack of charging infrastructure, unfamiliarity with the technology).
3. Discuss where and when people may be most in need of charging stations (those who commute long distances, live in shared/rental housing, or are travelling, etc.)
4. Have students investigate types of EV chargers on the market and determine what differentiates them from one another. Why would charger types be important when considering new locations for chargers?
5. Have students use apps or other resources to determine current locations of EV chargers in their state or area. <https://www.511virginia.org/>
6. Using the sources provided by the teacher or identified by students, analyze data about existing charging stations (are they all in one area, located at recreational sites, restaurants, in affluent areas, etc.). Students can overlay various layers of data to identify relationships.
7. Identify potential locations/needs for additional charging stations.
8. Have students create a presentation utilizing facts and information gained during their research and discussions to suggest additional charging station locations. Students should provide supporting data and their rationale for selecting the locations they chose. A sample rubric for the presentation is provided on page 5.

Modifications

Based on student needs, teachers can provide the maps and data for current charging stations versus having student research and find the sources of information needed. Analysis of data can be done independently, in small groups, or as a larger teacher-led discussion.



Extension

Have students further investigate trends in EV technology:

- Are their industry initiatives underway to standardize charging ports?
- What happens to batteries of EV's once they reach their end of life?
- Are there other alternative fuel technologies that seem to be gaining momentum in the marketplace?
- What are unique challenges that heavy duty commercial vehicles face when changing to EV technology?

Careers to Explore

- Cartographer
- Electrical Engineer
- Urban Planner

Terminology

Level 1 charging: Charging of EV from a typical wall-mounted standard residential power socket (120V). It is fairly slow charging and is commonly used overnight to charge an electric car battery.

Level 2 charging: Faster than Level 1 charging with an increased current and voltage (240V) rating. Level 2 chargers often need to be professionally installed.

Level 3 charging: Also known as “superchargers”. Uses 480-volt direct current (DC) for the fastest way to charge an electric vehicle. Usually, it charges to 80% battery capacity in 30 minutes. Because of their extremely high 480-volt draw, superchargers require heavy-duty commercial planning and wiring that most residential neighborhoods can't support.

Hybrid Electric Vehicle (HEV): a vehicle that has one or more energy sources along with electricity. A combination of gasoline and electricity power is widely used in hybrid electric vehicles.

Internal Combustion Engine (ICE): an engine powered by fuel in the form of diesel or gasoline. Internal combustion engines were the standard for vehicles for more than a century.

Charging station: An infrastructure that provides the facility to charge an electric vehicle.

Inverter: An electronic circuit component that changes Direct Current (DC) to Alternating Current (AC)

Electric Vehicle (EV): a vehicle that uses electricity as a source of energy for propulsion. They are classified as Battery Electric Vehicle, Hybrid Electric Vehicle, and Plug-in Hybrid Electric Vehicle

kW (1 kilowatt = 1,000 Watts) The basic measurement of an EV's power that is generated by its batteries.

kWh (kilowatt-hour): The basic measurement of an EV's energy – how much power (kilowatts) it can supply over a period of time (hours).

kWh/km: energy required to travel a kilometer

Range: The total distance an electric vehicle can travel on one full charge before the battery needs to be recharged.

SAE J1772 Connector: Also known as a **J plug**, is a North American standard for electrical connectors for electric vehicles. In North America, every electric vehicle manufacturer (except Tesla) uses the SAE J1772 connector, for Level 1 (120 volt) and Level 2 (240 volt) charging.

State of Charge (SoC): State of Charge (SoC) is the level of charge of an electric battery relative to its capacity. The units of SoC are percentages (0% = empty; 100% = full)

Tesla Connector: Tesla uses a proprietary connector that accepts all voltage for level 1, level 2 and DC fast charge. Only Tesla vehicles can use their DC fast chargers, called superchargers. Tesla installs and maintains these stations, and they are for the exclusive use of Tesla customers. Even with an adapter cable, it would not be possible to charge a non-tesla EV at a Tesla Supercharger station. That's because there is an authentication process that identifies the vehicle as a Tesla before it grants access to the power. Per [EV Charging Connector Types | Enel X](#).

See the Electric Vehicle Glossary links in the Resources section for other terms that may be useful for students to learn.

ELECTRIC VEHICLE (EV) PRESENTATION RUBRIC

Present what you learned about EVs and charging infrastructure needs. Include suggestions for additional charging stations and explain your selections.

	Beginning 1	Developing 2	Accomplished 3	Exemplary 4
Background Information	Provides no background information about EVs	Provides minimal or irrelevant background information about EVs	Provides sufficient and relevant background information so the audience can understand the topic	Provides in-depth, relevant information and data about the topic
Proposed Solution(s)	Provides no recommendations	Provides a recommendation without explaining the decision rational	Provides a recommendation with a weakly supported rational	Provides a recommendation with a thorough and logical rational supported by data
Knowledge About the Topics	Reads from slides and has no other information to add. Has difficulty answering questions about the information presented.	Reads from slides but adds information not included as appropriate. Has difficulty answering questions about the information presented.	Reads from slides but adds information not included as appropriate. Easily answers questions about the information presented with a good understanding of the topics.	Uses slides as reminders and visual engagement, but does not rely on them for the discussion. Easily answers questions about the information presented with thorough knowledge on the topics.
Visual Interest & Audience Engagement	The presentation is not visually interesting - AND - The presenter does not engage the audience in discussion.	The presentation is visually interesting - OR - The presenter engages with the audience in discussion.	The presentation is visually interesting - AND - The presenter engages with the audience in discussion.	The presentation is visually interesting with varying graphics - AND - The presenter encourages and seems to enjoy discussion with the audience.

Electric Vehicle Charging



- hybrid
- level 1
- inverter
- station
- supercharging
- kilowatt
- range
- J plug
- combustion
- state

The crossword puzzle grid consists of black and white squares. The numbered starting points are:

- 1: Down, 2 squares
- 2: Down, 3 squares
- 3: Down, 10 squares
- 4: Across, 8 squares
- 5: Across, 6 squares
- 6: Down, 7 squares
- 7: Down, 4 squares
- 8: Across, 5 squares
- 9: Across, 10 squares
- 10: Across, 6 squares

ACROSS

- 4) An internal _____ engine was the standard power source for vehicles for over a century.
- 5) The total distance an electric vehicle can travel on one full charge before the battery needs to be recharged.
- 8) A vehicle's _____ of charge is the level at which a battery is charged relative to its capacity.
- 9) An electronic circuit component that changes direct current (DC) to alternating current (AC) or vice versa.
- 10) The North American standard electrical connection for electric vehicles.

DOWN

- 1) A charging _____ is the infrastructure in place which allows for charging an electric vehicle's batteries.
- 2) The basic measurement of an EV's power that is generated by its batteries.
- 3) Another term for Level 3 or fast DC charging.
- 6) 120-Volt charging that can be done using a residential wall socket.
- 7) A vehicle with a combination of energy sources. It may use an electric and gasoline powered engine.

RESOURCES

[Understanding Electric Vehicle Terms | General Motors \(gm.com\)](#)

[Electric Vehicle Glossary: The Complete List of Electric Car Terms \(getelectricvehicle.com\)](#)

https://afdc.energy.gov/fuels/electricity_stations.html

<https://www.511virginia.org/>

<https://chargehub.com/en/countries/united-states.html>

<https://www.plugshare.com/>

[Electric Vehicle Market Size, Share & Analysis Report, 2019-2025 \(kbvresearch.com\)](#)

[How to Understand Electricity: Watts, Amps, Volts, and Ohms - Owlcation](#)

[EV Charging Connector Types | Enel X](#)