

# Drivetrain Lab Teacher Guide: Environmental Science

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## At a glance

Students use a free online lab to answer one question: **which car is better for the air, and does it depend on where you live?** They read a stacked bar graph, compare four cars, then move the same electric car to different states and watch its number change.

|                 |                                                                                                  |
|-----------------|--------------------------------------------------------------------------------------------------|
| Course          | High school Environmental Science, Earth Science or Biology (grades 9–12); adaptable for grade 8 |
| Time            | 45–55 minutes, an 80–90 minute block, or two class periods                                       |
| Grouping        | Pairs                                                                                            |
| Devices         | One laptop, Chromebook or tablet per pair; phones work in a pinch                                |
| Materials       | Drivetrain Lab: Classroom Edition (free, no login) and the guided sheet in this guide            |
| Prior knowledge | Carbon dioxide is a greenhouse gas; fossil fuels release CO <sub>2</sub> when burned             |
| Product         | Guided sheet + claim–evidence–reasoning exit ticket                                              |

**The tool.** Drivetrain Lab: Classroom Edition opens with four similar-sized SUVs: a Tesla Model Y (electric), Toyota RAV4 Plug-in Hybrid, Toyota RAV4 Hybrid and Honda CR-V (gas). Students can change the state, miles driven and climate. **Reset to the starting example** brings back the settings the answer key uses: Arizona, 12,000 miles a year, hot summers.

**Using a different starting state.** Keep the class on the reference settings for Part 1 so answers match the key. Students switch to your own state in Part 2.

## Standards and objectives

The lesson supports human-impact and energy standards and gives practice reading data displays.

| Framework                         | Connection                                                                                                                                                                                                                                             |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NGSS performance expectations     | HS-ESS3-4 (evaluate a technological solution that reduces human impacts on natural systems); HS-ESS3-6 (use a computational representation of how human activity modifies Earth systems); HS-ETS1-3 (evaluate solutions using criteria and trade-offs) |
| Science and engineering practices | Analyzing and interpreting data; using mathematics and computational thinking; engaging in argument from evidence                                                                                                                                      |
| Crosscutting concepts             | Cause and effect; energy and matter; systems and system models                                                                                                                                                                                         |

### Students will be able to:

1. Name the three sources of a car’s carbon dioxide: the factory, the fuel supply, and the engine or power plant.
2. Read a stacked bar graph and compare values in a table.
3. Explain why the same electric car is cleaner in some states than in others.
4. Tell apart carbon dioxide (climate) and smog (local air quality).

**Vocabulary:** carbon dioxide (CO<sub>2</sub>), greenhouse gas, lifecycle, fossil fuel, electric grid, renewable energy, smog, tailpipe.

## Choose your schedule

Pick the column that matches your class length; minutes for each part are listed, and a dash means that part is skipped or assigned for later.

| Part                                      | Short period (45-55 min) | Block (80-90 min) | Two days (2 × 45-55 min)            |
|-------------------------------------------|--------------------------|-------------------|-------------------------------------|
| Warm-up                                   | 5                        | 10                | Day 1: 8                            |
| Vocabulary and demo                       | 7                        | 10                | Day 1: 12                           |
| Part 1: Read the bars                     | 15                       | 20                | Day 1: 25                           |
| Part 2: Move the car                      | 10                       | 15                | Day 2: 15 (after a 5-minute review) |
| Part 3: Smog vs. CO <sub>2</sub>          | —                        | 10                | Day 2: 10                           |
| Part 4: Make a recommendation (extension) | —                        | —                 | Day 2: 12                           |
| Share out                                 | 5                        | 7                 | Day 1: 5                            |
| Exit ticket                               | 8                        | 8                 | Day 2: 8                            |
| <b>Total</b>                              | <b>50</b>                | <b>80</b>         | <b>50 + 50</b>                      |

**Shorter still (30-40 minutes):** run the demo, Part 1 and the exit ticket, and project Part 2 as a whole-class demonstration.

**Block over 90 minutes:** add Part 4.

## Lesson sequence

Each part matches a row in the schedule table and a part of the guided sheet.

**Warm-up.** Show a photo of a gas pump next to a charging cable and ask: “Where does the energy in each one come from?” Build two chains on the board with the class:

- Oil well → refinery → truck → gas station → car engine
- Power plant (coal, gas, solar, wind, water, nuclear) → power lines → charger → car battery

**Vocabulary and demo.** Introduce the vocabulary with the chains still visible. Project the lab and point to each colored part of a Question 1 bar: tan for building the car, gold for producing fuel, gray for burning fuel in the engine or at the power plant. Read one bar aloud together, then show where the Reset button is.

**Part 1: Read the bars.** Pairs fill in the table for the four starting cars, circle the lowest and box the highest, then answer questions 1-3. Ask pairs who finish early: “Why is the electric car’s tan part the biggest?”

**Part 2: Move the car.** Pairs change the state to West Virginia, then Washington, then your own state, recording the electric car’s total each time. Sentence frames on the sheet help them explain the change. Connect West Virginia to coal and Washington to hydropower.

**Part 3: Smog vs. CO<sub>2</sub>.** Pairs find the smog rating in Question 2 and answer questions 7-8. Clarify that smog affects the air people breathe nearby, while CO<sub>2</sub> warms the whole planet.

**Part 4: Make a recommendation (extension).** A family in your town drives about 12,000 miles a year and needs an SUV. Pairs set the lab to your state and write a three-sentence recommendation with one number as evidence. Volunteers read theirs aloud.

**Share out.** Three pairs each report one surprise. Ask the class which variable mattered most.

**Exit ticket.** Students answer the driving question on their own using claim, evidence and reasoning.

## Student guided sheet: Which car is better for the air?

Copy this section into its own document for students. Cross out any part your schedule skips.

Name: \_\_\_\_\_ Partner: \_\_\_\_\_ Class: \_\_\_\_\_

**Part 1: Read the bars.** Press Reset to the starting example. Look at Question 1 and write each car's total (the number at the end of its bar).

| Car                 | Type           | Total g CO <sub>2</sub> per mile |
|---------------------|----------------|----------------------------------|
| Tesla Model Y       | Electric       |                                  |
| RAV4 Plug-in Hybrid | Plug-in hybrid |                                  |
| RAV4 Hybrid         | Hybrid         |                                  |
| Honda CR-V          | Gas            |                                  |

1. Circle the car with the lowest total. Put a box around the highest.
2. The tan part of each bar is building the car. Which car has the biggest tan part? \_\_\_\_\_ Why do you think so?  
\_\_\_\_\_
3. The electric car has no tailpipe. Why does it still have a gray "burning" part? \_\_\_\_\_

**Part 2: Move the car.** Change the state and write the electric car's total.

| State                      | Model Y total g CO <sub>2</sub> per mile |
|----------------------------|------------------------------------------|
| Arizona (starting example) |                                          |
| West Virginia              |                                          |
| Washington                 |                                          |
| Our state: _____           |                                          |

4. The electric car is cleanest in \_\_\_\_\_ because \_\_\_\_\_.
5. It is dirtiest in \_\_\_\_\_ because \_\_\_\_\_.
6. Did the gas car's number change much when you changed states? Why or why not? \_\_\_\_\_

**Part 3: Smog vs. CO<sub>2</sub>.** Look at Question 2.

7. Which car has the best smog rating? \_\_\_\_\_ What is its rating? \_\_\_\_
8. Smog hurts the air we breathe nearby. CO<sub>2</sub> warms the whole planet. Which car is best for both? \_\_\_\_\_

**Part 4: Make a recommendation (if assigned).** A family in our town drives about 12,000 miles a year and needs an SUV. Set the lab to our state.

9. I recommend the \_\_\_\_\_ because \_\_\_\_\_. My evidence is \_\_\_\_\_.

**Exit ticket.** Which car is better for the air where you live?

- Claim: \_\_\_\_\_
- Evidence (use a number): \_\_\_\_\_
- Reasoning (why?): \_\_\_\_\_

## Answer key

Values come from the lab's starting example (Arizona, 12,000 miles a year, hot summers); answers within a few grams are correct.

### Part 1

| Car                      | Total g CO <sub>2</sub> per mile |
|--------------------------|----------------------------------|
| Tesla Model Y (electric) | 143 (lowest)                     |
| RAV4 Plug-in Hybrid      | 190                              |
| RAV4 Hybrid              | 293                              |
| Honda CR-V (gas)         | 405 (highest)                    |

1. Lowest: Model Y. Highest: CR-V.
2. The Model Y. Its big battery takes a lot of energy to make.
3. The electricity comes from power plants, and many of them burn coal or natural gas.

## Part 2

| State         | Model Y total |
|---------------|---------------|
| Arizona       | 143           |
| West Virginia | about 318     |
| Washington    | about 85      |

4. Washington (or Vermont, at about 56), because its electricity comes mostly from water (hydropower) and other sources that burn no fossil fuel.
5. West Virginia, because most of its electricity comes from burning coal.
6. No, it stays at 405. A gas car burns gasoline, which is about the same everywhere; it doesn't use the electric grid.

## Part 3

7. The Model Y, with a smog rating of 10 (no tailpipe).
8. The Model Y: lowest CO<sub>2</sub> and best smog rating in most states.

**Part 4:** any car is acceptable if the reason and the number support it. Strong answers mention the state's grid.

## Exit ticket scoring (3 points)

| Points        | A complete answer                                                                                                                                                                          |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Claim (1)     | Names a car or type, for example "the electric car is better for the air here"                                                                                                             |
| Evidence (1)  | Gives a number from the lab, for example 143 vs. 405 g CO <sub>2</sub> per mile in Arizona                                                                                                 |
| Reasoning (1) | Explains why, for example "our electricity comes partly from cleaner sources than burning gasoline"; full credit when it notes the answer could change in a state that burns a lot of coal |

## Teaching notes

The biggest hurdle is usually reading the stacked bar, so model one bar aloud before pairs start.

## Misconceptions to watch for

- "Electric cars cause no pollution." The bar shows pollution from building the car and from power plants.
- "The battery makes electric cars worse." Building one does cause more CO<sub>2</sub>, but in most states the car makes that up within a year or two of driving.
- "Smog and CO<sub>2</sub> are the same thing." Smog harms the air nearby; CO<sub>2</sub> warms the whole planet.
- "Hybrids plug in." Only plug-in hybrids charge from an outlet; a regular hybrid recharges itself while driving.

## Supports

- Pair stronger and newer readers, and give each partner a role (driver of the device, recorder).
- Pre-fill the first row of the Part 1 table as a model.
- Post the sentence frames and the energy chains from the warm-up where everyone can see them.
- Let students point to the bar and answer orally, and accept drawings for question 3.
- For multilingual learners, pair the vocabulary with pictures (smokestack, tailpipe, battery, solar panel).

## Challenge

- Try a Toyota Prius against a Ford F-150 and explain why vehicle size matters.
- Change the miles driven to 5,000 and 25,000. Which car's advantage grows with more driving?

- Older or advanced students can try the companion tool, Drivetrain Cost Lab for Car Shoppers, to see whether the cleanest car is also the cheapest to own.

### **Technology setup**

- Open the lab on a student device before class to confirm your school's network allows it.
- No accounts or logins are needed, and the lab collects no student data. Settings are saved only in each browser.
- If devices are short, run Part 1 on a projector as a class and give each pair a device for Part 2.

### **Where the numbers come from**

The lab uses EPA fuel-economy ratings, EPA eGRID2023 state grid emissions, Argonne National Laboratory figures for gasoline, published estimates for building cars and batteries, and University of Michigan estimates of how far cars are driven over their lives. The page's "How the numbers are calculated" section explains every step.