Chemistry:

Greenhouse Gases Carbon Footprint

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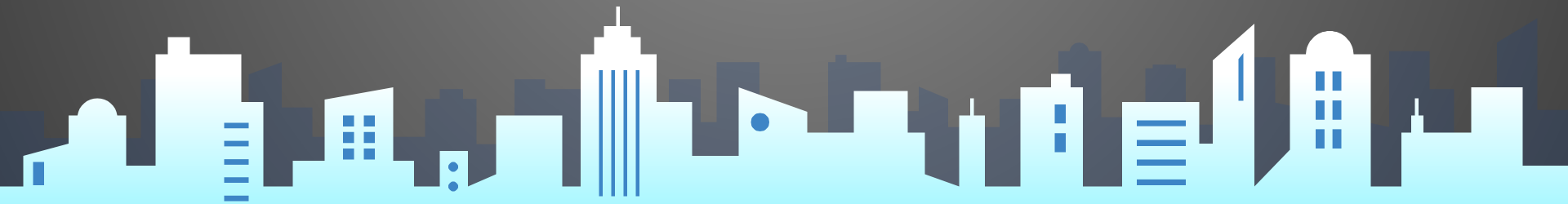


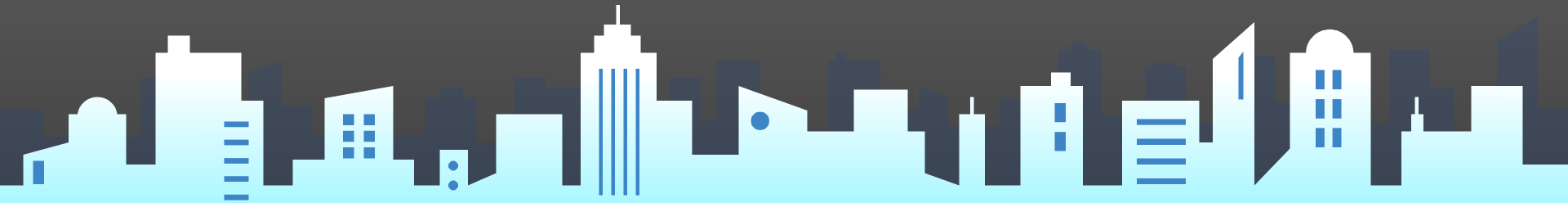
NGSS Standards

Disciplinary Core Idea

- **PS1.B** Chemical Reactions
- **ESS3.D** Global Climate Change

Science/Engineering Practices:

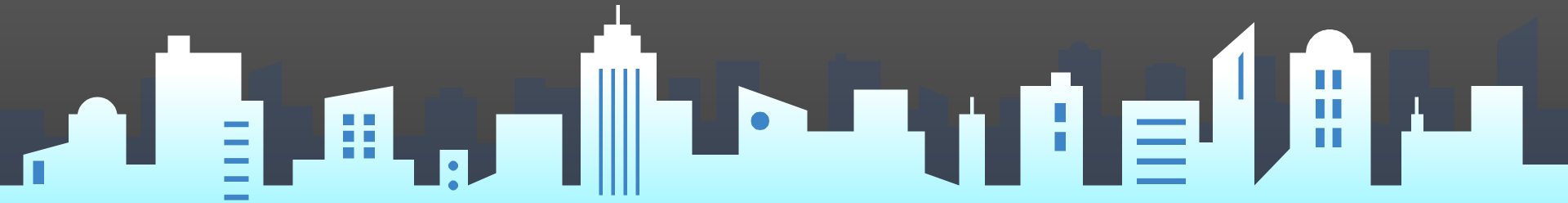
- Using mathematical/computational thinking
- analyzing & interpreting data



NGSS Standards

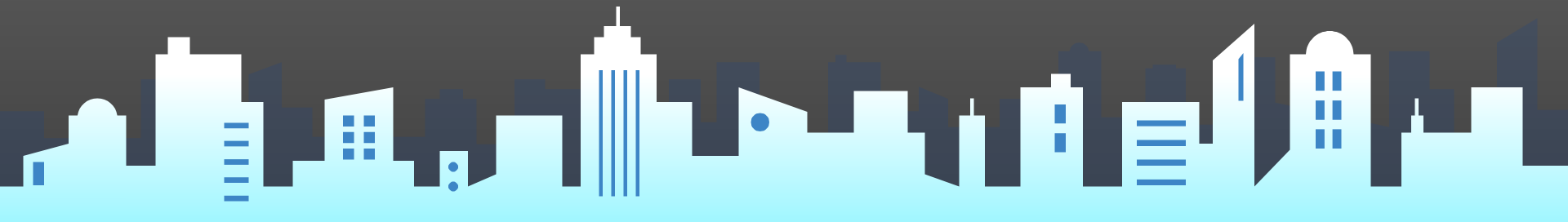
Performance Expectations

- **HS-PS1-1** Use periodic table predict pattern of properties **(combustion reactions)**
- **HS-PS1-7** Mathematically represent conservation of mass in chemical reactions **(balance equations)**
- **HS-ESS3-6** Computationally represent relationships among Earth systems and how human activity changes the relationship **(carbon footprint)**



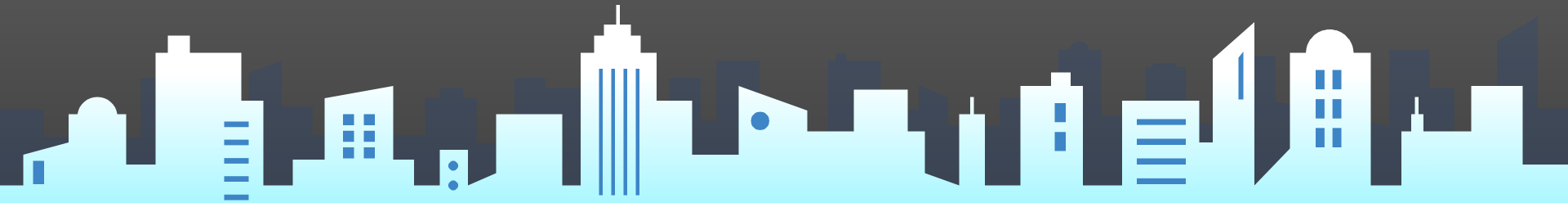
Student Learning Objectives

Given data on the top 2 greenhouse gas sources in CA, students will be able to **calculate their carbon footprint** and **analyze relationships** between their everyday lives and CO2 emissions that contribute to climate change. Students will also compare their footprints to the average footprint in our class, the US and the world.



Placement in Unit (Student Knowledge)

- Students just finished learning about fossil fuels (what they are, combustion, energy)
- Second day of learning about greenhouse gases, negative effects of burning fossil fuels, carbon footprint previously mentioned
- A lot of data is student generated



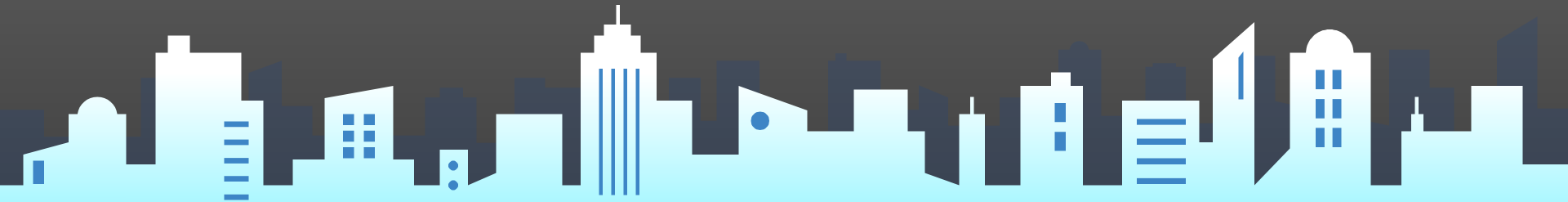
Rationale

Principle:

- Engage students in lessons that are relevant to their daily lives.
- To recognize and support sense making practices by students and value student's ideas. (brainstorm)

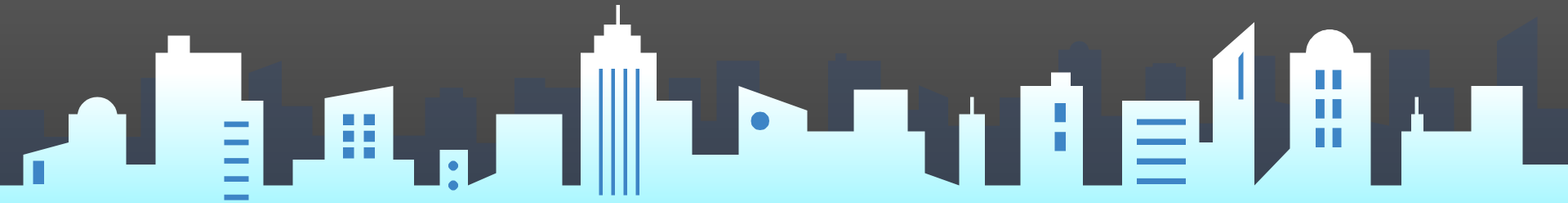
Equity:

- relevant material no matter economic/social status
- low materials

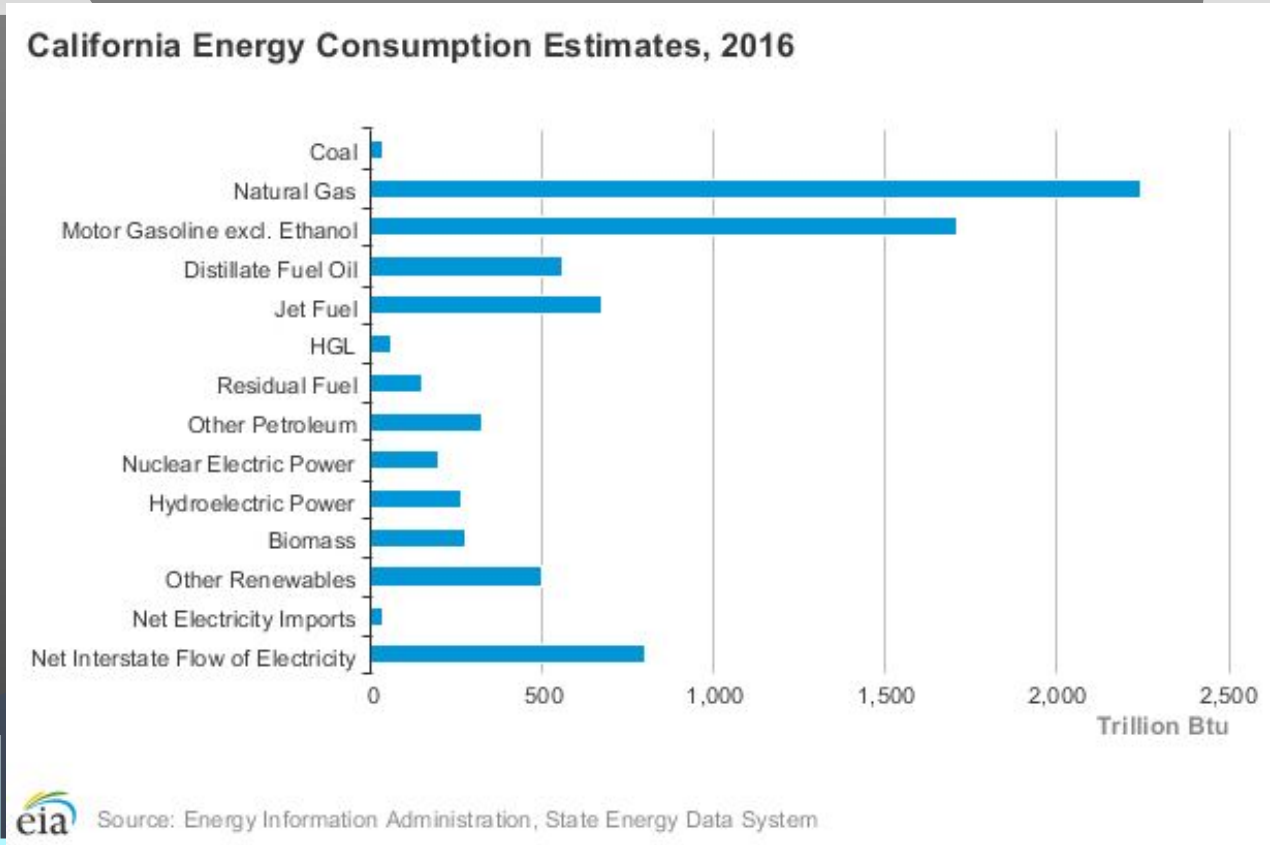


Lesson Overview

- **Brainstorm** things that contribute to carbon footprint
- Students **hypothesize** what activity in their lives contributes most to their footprint (ex. Driving, AC...)
- What are top 2 greenhouse gas sources in CA? What used for?
- Calculate carbon footprint based on top 2 factors
- Stoichiometry calculation
- **Discussion** of results and criteria for solutions



What are top 2 greenhouse gas sources in CA?



Students will calculate carbon footprint

Estimate your CO2 production from natural gas by answering the following questions:

1. How many miles do you commute between school and home in a day by a gas fueled vehicle?
   (bus or parents driving included! 0 if you bike/walk to school)

2. How many miles do you commute to school a year by a gas fueled vehicle?
   (180 days/school year)

3. If you work, how may miles do you commute to work by gas fueled vehicle?
   Figure out how many miles per year. (52 weeks in a year)

4. Any other regular trips by gas fueled vehicle in a year? How many miles?
   (ex. Visiting friends, vacation to LA)

Students will calculate carbon footprint

5. Total miles ride/drive per year= _____

6. Look up the average miles per gallon of gasoline for your primary mode of transportation. (ex. Mom's car, or city bus) The average vehicle in the US gets about 21.6 mpg of gasoline.

7. 1 gallon = 3.785 L How many liters of gasoline do you use per year?

8. The density of gasoline is 0.7 kg/L How many kilograms of gasoline did you use?

What is combustion formula?

Gasoline (mostly octane) C_8H_{18}

$$2\,C_8H_{18} + 25\,O_2 \rightarrow 16\,CO_2 + 18\,H_2O$$

6.8 miles to SJSU → 2,448 miles/school year (180 days)
3 miles to work → 1,500 miles/year
Total = 3,948 miles/year

$$\left(\frac{3948\ \text{miles}}{\text{year}}\right)\left(\frac{\text{gal}}{21.6\ \text{miles}}\right) = 182.8\ \text{gal/year}$$

$$\left(\frac{182.8\ \text{gal}}{\text{year}}\right)\left(\frac{3.8\ \text{L}}{\text{gal}}\right) = 694.6\ \text{L/year}$$

$$\left(\frac{694.6\ \text{L}}{\text{year}}\right)\left(\frac{0.7\ \text{kg}}{\text{L}}\right) = 486.2\ \text{kg/year octane}$$

Density

$$\frac{2\,C_8H_{18}}{16\,CO_2} = \frac{486200\ \text{g}\ C_8H_{18}}{x\ \text{g}\ CO_2}$$

Molar ratios

$$x = 3,889,600\ \text{g}\ CO_2$$

$$\left(\frac{3889600\ \text{g}\ CO_2}{1}\right)\left(\frac{\text{lbs}}{454\ \text{g}}\right) = \boxed{8,567.4\ \text{lbs}\ CO_2}$$

Carbon footprint continued...

CA's other top greenhouse gas sources is gasoline, which mostly consists of octane (**C_8H_{18}**). Write and balance the equation for the combustion of octane.

In CA, natural gas is used to generate electricity, heating homes, running AC and cooking. On average, each person in CA uses **39.36 kg of natural gas per year**. Complete the calculations to find the average pounds of CO_2 produced from natural gas per year. (1 kg = 2.2 lbs)

Add your answer to your total CO_2 from octane per year to find your total carbon footprint.

Total carbon footprint= lbs CO_2 from octane + lbs CO_2 from methane

Analysis/Reflection

Compare your carbon footprint with each footprint below and explain why you think the results turned out the way it did.

vs. Class Average Carbon Footprint of _____lbs of CO2/year

vs. US Average Carbon Footprint of 36,000 lbs of CO2/year

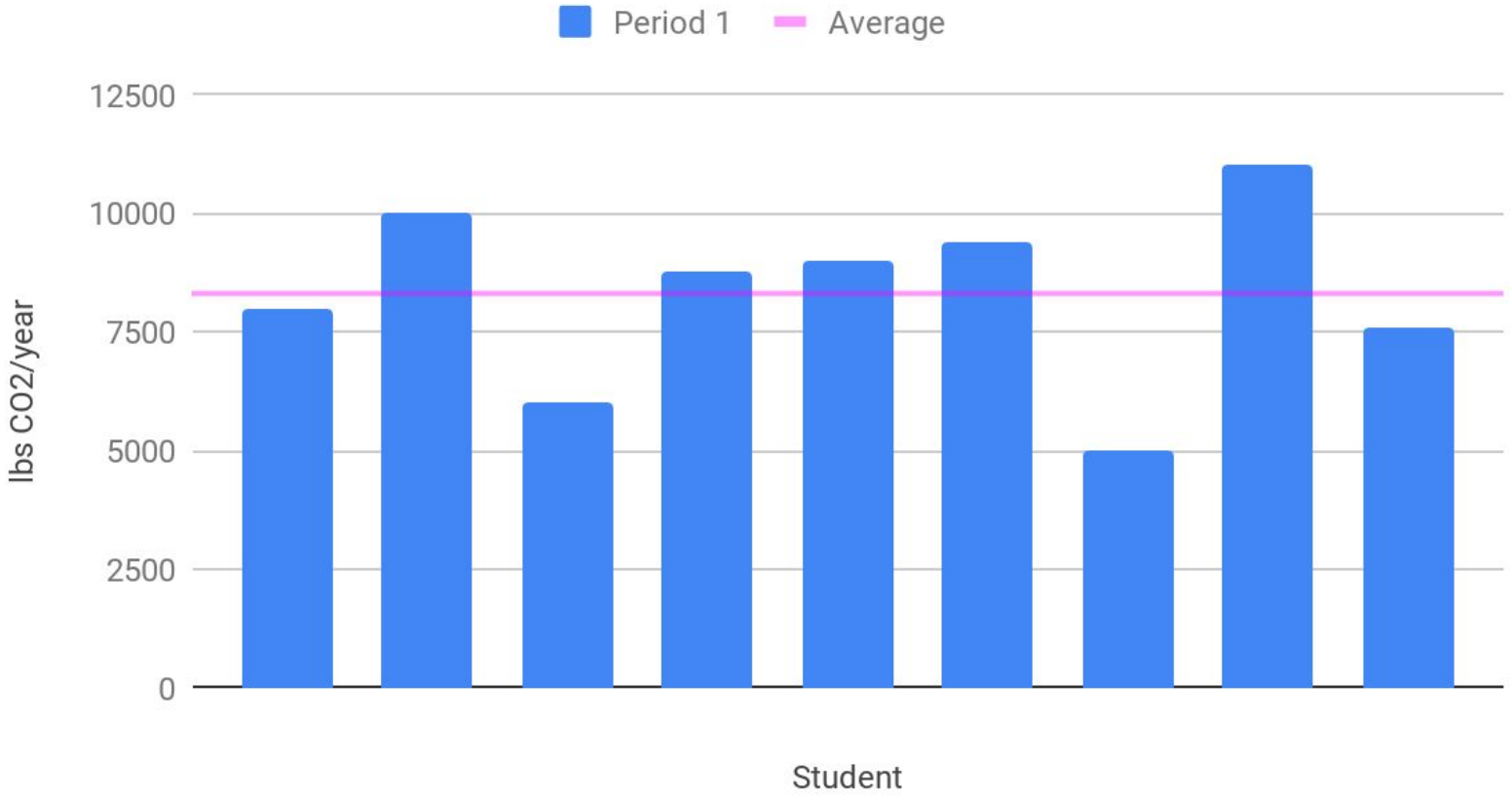
vs. World Average of 9,000 lbs of CO2/year

Were you surprised by the results? What factors do you think contribute to the US carbon footprint being higher than the world's average?

How could you reduce your carbon footprint? Are these adjustments realistic?

What other factors contribute to your carbon footprint that were not included in CA's top 2 greenhouse sources? How would those factors impact your results?

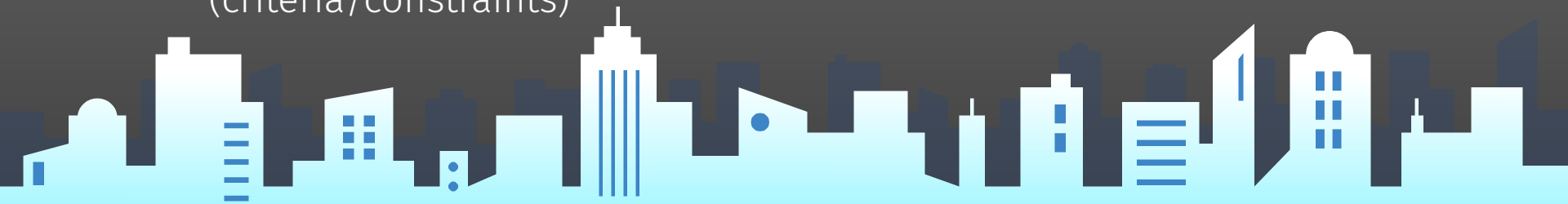
Class Carbon Footprint



Teacher will...

- Demo sample calculation
- Shared slide where students mark carbon footprint
- Discuss analysis/reflection:
  - Surprised by results?
  - Are changes feasible? Constraints?
  - What are other factors contribute to footprint?

Next lesson will relate to energy alternatives (criteria/constraints)



Formative Assessments

- Brainstorm in beginning
- Predict greatest factor
- Actual footprint calculation
- Discussion at end of class