

Transportation Analysis 101

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BECOMING A TRANSPORTATION ANALYST

Through a series of readers and assignments, the Transportation Assessment packet is designed to train you to analyze the environmental footprint of different transportation options. Readers contain all the information you need to complete each assignment.

As a transportation analyst you will learn how to do the following.

- Explain the relationship between transportation and climate change
- Define renewable and non-renewable feedstocks
- Compare varied renewable and non-renewable fuels on energy density, cost, and greenhouse gas emissions
- Explain the differences between electric vehicles, hybrid vehicles, compressed air vehicles, and hydrogen vehicles
- Analyze the benefits of varied personal automobiles
- Calculate CO₂ savings from using public transportation
- Explain barriers to widespread public transportation use
- Understand the modes and means of transportation
- Evaluate different means of transportation and plan an itinerary
- Understand the environmental ramifications of transportation decisions

VOCABULARY

Transportation: movement from one place to another of people and/or objects

Greenhouse gases: gases in the atmosphere that can trap infrared heat radiation coming from Earth. Common greenhouse gases in the Earth's atmosphere include water vapor, carbon dioxide, methane, and nitrous oxide

Greenhouse Effect: the warming effect caused by greenhouse gases (GHGs) trapping infrared radiation in the atmosphere. The Greenhouse Effect is vital to maintaining a hospitable climate for life on Earth, but swelling concentrations of GHGs in the atmosphere are increasing the Greenhouse Effect leading to rising global temperature and climate change

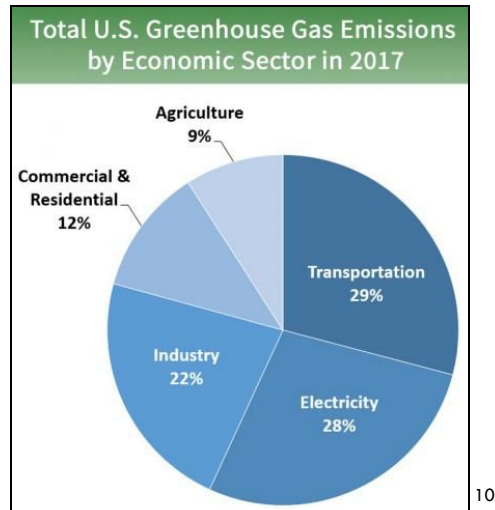
Carbon Cycle: the combined processes, including photosynthesis, decomposition, respiration, and combustion, by which carbon cycles between its major reservoirs - the atmosphere, oceans, underground, and living organisms

Carbon Footprint: the total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company.

Fuel: any material that can be used as an energy source

INTRODUCTION: GREEN TRANSPORTATION

- Transportation accounts for 29% of **greenhouse gas emissions** in the United States.⁹ Reducing travel-related emissions is a key strategy for decreasing our **carbon footprint**.



If you have a device and internet accessible, watch this 8 minute video from Our Changing Climate about travel-related emissions:

<https://www.youtube.com/watch?v=TkXEU5ng8rE>

Some examples of transportation methods are: public transportation (bus, subway, bike share), private transportation (car, walking, biking), carpooling, and plane.

1. What are some ways in which you use transportation?

2. How can you reduce your contribution to transportation emissions?

⁹ "Sources of Greenhouse Gas Emissions," *Greenhouse Gas Emissions*. United States Environmental Protection Agency, April 11, 2019, <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>. (accessed January 21, 2020).

¹⁰ "Ibid.

READER: TRANSPORTATION FUEL

What is Fuel?

- **Fuel** is something consumed to release energy. Fuels can be *combustible* materials such as wood, coal, gas, or oil - burned to produce heat or power, *fissionable* material - used in a nuclear reactor, or *nutritive* material - metabolized by a living organism (food). In this lesson we'll discuss combustible fuels.
- When compounds undergo a chemical reaction, atoms and molecules are rearranged through the process of breaking bonds and forming new ones, and energy is released. When this process is accompanied by heat, it is called **combustion**. At least 75% of our energy needs are met through the combustion of fossil fuels.
- Combustible fuels typically contain one or several combustible elements like carbon, hydrogen, or sulphur. Through a process called combustion, chemical changes take place that release heat energy. This energy then powers the engine that makes your car, bus, or airplane move.

Fuel Use Over Time

- While fuel has played a critical role in the development of human history, it's important to note that fuel sources have changed over time. The 24-hour clock metaphor is a helpful way to visualize this change over time.
- If 200,000 years of human history were condensed into 24 hours, for 23.75 of those hours humans transported themselves and their goods without using combustible fossil fuels. How long have we been using fossil fuels to power our trains, ships, cars, and planes using the 24-hour history metaphor? *Answer: for the last 15 minutes.*

Energy Sources for Transportation

- The Earth provides a variety of energy sources. Sunlight is the main source of energy on Earth – from broccoli to fossil fuels to solar to wind energy, the sun powers life on Earth.
- Plants convert sunlight into chemical energy through photosynthesis. This energy is used to power the activities of the plant, and it also powers the activities of the animals that eat those plants. When humans eat plants, or other animals that are powered by eating plants, we are using energy from the sun to fuel our activities, including human-powered modes of transport like walking, and biking, and riding transport animals, such as horses.
- Humans burn, or combust, fuels to power our transport. Combustible fuels can be renewable: wood and biofuels, or they can be non-renewable fossil fuels: coal, natural gas, and petroleum. Fossil fuels are fossilized plant and animal matter that have been under extreme heat and pressure for millions of years. This dense form of sunlight energy is a powerful fuel

Types of Fuels

- According to the U.S. Energy Information Administration, 28% of U.S. energy goes toward moving people and goods around.¹¹ This energy comes in a variety of different types of energy sources we call fuels. The table below lists a number of different fuel types, how they are used, and whether they are **renewable** or **nonrenewable**.

Fuels	Modes of Transport	Renewable or Nonrenewable?
Bio-Jet Fuel	Airplanes	Renewable
Bio-Methane	Compressed Natural Gas Cars	Renewable
Biodiesel	Diesel cars, buses, and trucks	Renewable
Compressed Natural Gas (CNG)	CNG cars	Renewable or Non-Renewable – depending on the fuel source used to produce the gas.
Diesel	Diesel cars, buses, and trucks	Non-Renewable
Electricity	Electric cars, cable cars, subway systems	Renewable or Non-Renewable – depending on the fuel source used to produce the electricity.
Ethanol	Cars (special vehicles?)	Renewable
Gasoline	Cars, boats	Non-Renewable
Hydrogen	Space shuttles	Non-Renewable
Jet Fuel	Airplanes	Non-Renewable
Methanol	Monster Trucks, drag racers	Non-Renewable
Vegetable Oil	Veg Oil cars	Renewable
Coal	Trains	Non-Renewable

¹¹ “Use of energy explained“ United States Energy Information Administration. May 10, 2019. <https://www.eia.gov/energyexplained/use-of-energy/transportation.php> (accessed March 23, 2020).

What is Sustainable Fuel?

- Sustainable fuels are renewable, but renewable fuels are not necessarily sustainable. Recall the definition of sustainability. Sustainable energy sources, or feedstocks, can be renewed at or faster than the pace of consumption, which is also true of Renewable fuels. However, Sustainable fuels are also locally available and have a relatively light impact on the environment so that the ecosystem continues to be fertile and support biodiversity. One of the most complex issues in green transportation is the competition between producing food and fuels on productive farmland. As a transportation analyst, you will continue to wrestle with the complexities of sustainability – balancing the sometimes competing interests of people, the planet, and profitability – when considering fuel choices.
- The good news is that energy is fungible – or easily substituted, and we have alternatives. The challenge ahead of us is to make sustainable fuels the most attractive choice.

How do we choose transportation fuels?

- What are the factors we use to determine which energy sources we use to power our transportation? Price, performance, availability/convenience, compatibility with our mode of transportation, and fueling infrastructure are some of the ways that we make this decision. If electric vehicles cost the same, performed better, were less expensive to fuel, and if recharging was convenient, would you make the switch? What energy feedstock could you use to make this a sustainable choice



If you have a device and internet accessible, watch “The Oil Journey” from the Post Carbon Institute (watch from minutes 3:16-14:27)

- <http://www.youtube.com/watch?v=Sv2MHEDIXIU>

ASSIGNMENT: ROADTRIP: RENEWABLE VERSUS NON-RENEWABLE ENERGY SOURCES

- Review the Table below. Notice that each fuel source has a different **energy density** and amount of CO₂ emitted when combusted.

Table: Energy Density and CO₂

Fuel Source	Energy Density MMBtu/gal	GHG emissions lbs CO₂/gal¹²
Ethanol (85%)	.11	12.65
Gasoline	.16	19.32
Diesel	.18	22.46
Biodiesel (100%)	.17	20.79
Compressed Natural Gas	.0001	.0159

Source: Local Government Operations Protocol For the quantification and reporting of greenhouse gas emissions inventories. Version 1.1, May 2010

1. Which fuel sources have the highest energy densities and which sources emit the most CO₂?
2. Based on the information provided in the table, which fuel source(s) are the most sustainable?
3. The GHG emissions number provided below include only the emissions from the tailpipe of a vehicle. Where else might GHG's be emitted before entering a vehicle?

¹² This measurement is the amount of CO₂ released at tailpipe

Imagine you are renting a car to drive from Los Angeles to San Francisco. How would you decide which car to drive? Use the table below to fill in the chart. Choose two fuel sources (1 renewable and 1 non-renewable) from the chart, using the miles between Los Angeles and San Francisco, and calculate the number of gallons, total CO₂ emissions, and fuel cost for the trip.

Fuel Source	GHG emissions lbs CO ₂ /gal	National Average Price per Gallon (April 2017 ¹³)		Transportation Options	Highway Fuel Efficiency (MPG = miles per gallon)
Ethanol (85%)	12.65	\$2.11 (E85)		2017 Ford Focus FFV	23MPG
Gasoline	19.32	\$2.38 (regular)		2017 Ford Focus FWD	31MPG
Diesel	22.46	\$2.55		2017 Chevy Cruze Diesel	52MPG
Biodiesel (100%)	20.79	\$3.09 (B99-100)		2017 Chevy Cruze Diesel	43MPG
Compressed Natural Gas	.0159	\$2.15/GGE (gallon gas equivalent)		2015 Honda Civic Natural Gas	38MPG

Renewable Fuel Source	Miles Traveled	Gallons of fuel required for travel	Total amount of CO ₂ produced?	Total fuel cost?
	383 miles	383 miles ÷ ___ MPG = _____ gallons	___ gallons x ___ lbs CO ₂ /gal = _____ lbs CO ₂	___ gallons x \$___/gallon = \$_____
Non Renewable Fuel Source	Miles Traveled	Gallons of fuel required for travel	Total amount of CO ₂ produced?	Total fuel cost?
	383 miles	383 miles ÷ ___ MPG = _____ gallons	___ gallons x ___ lbs CO ₂ /gal = _____ lbs CO ₂	___ gallons x \$___/gallon = \$_____

¹³ https://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2017.pdf