

# Carbon Offsets

## MAT095

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June 19, 2007

### 1 Introduction

This lesson discusses the arithmetic of each person's civic responsibility for their own carbon emissions. All of us use fossil fuels either directly or indirectly. An example of a direct use of fossil fuel would be when we operate an automobile. An example of an indirect use would be when we turn on a light in our house. We are all responsible, on an individual basis, for the greenhouse gasses we put into the atmosphere from the wattage we use in our households to the gasoline we burn in our cars. This particular lesson focusses on automobile emissions and how to reduce them directly or indirectly. An example of direct reduction would be simply to use less gasoline. An example of indirect reduction would be by planting a tree that would absorb CO<sub>2</sub>.

### 2 Project SENCER Example

There are many ways to reduce your carbon emissions in the atmosphere by what are called *offsets*. The idea is that each person makes a *carbon footprint* in their life time by using fossil fuels either directly or indirectly. Usually, the amount of carbon an individual produces is measured on a yearly basis. For example, if you drive a midsize car that averages 30 mpg, then your carbon footprint made by driving the car approximately 12,000 miles per year is about 3.28 tons. Now we have an equation assuming your car averages 30 mpg:

12,000 mi  $\approx$  3.28 tons CO<sub>2</sub>

**Question 1:** How many miles must you drive to produce 1 ton of CO<sub>2</sub>?

**Answer:** We set up a proportion.

$$\frac{12,000 \text{ mi}}{3.28 \text{ tons CO}_2} = \frac{x \text{ mi}}{1 \text{ ton}}$$

**Solving:**

$$(12000)(1) = 3.28x$$

Therefore,

$$x = \frac{12000}{3.28} \approx 3658.537$$

For our purposes, based on a 30 mpg car, we will say that:

$$1 \text{ ton CO}_2 = 3700 \text{ mi}$$

**Planting trees:** One method of eliminating your footprint is by reforestation. Since the advent of agriculture, approximately  $\frac{1}{2}$  of the world's forests have been eliminated. (See [www.carbonfund.org/site/](http://www.carbonfund.org/site/)). The good news is that if you plant a tree it will absorb carbon in its body and the soil where it is planted. The growth of one tree in one year will absorb the amount of CO<sub>2</sub> emissions generated by 1242 miles of driving (based on a 30 mpg car). Now we have another equation:

$$1242 \text{ miles} = 1 \text{ tree}$$

The next equation gives the cost of a tree.

$$1 \text{ tree} = \$12$$

(see <http://www.carbonbankusa.com/>).

**Question 2:** Based on the information above, how many trees will you need to plant in order to offset the emissions generated by 12,000 miles of driving? How much will it cost?

**Answer:** Again, we can set up a proportion.

$$\frac{1242 \text{ mi}}{1 \text{ tree}} = \frac{12000 \text{ mi}}{x \text{ trees}}$$

**Solving:**

$$1242x = 12000$$

Therefore,

$$x = \frac{12000}{1242} \approx 9.662 \text{ trees}$$

For our purposes we will round to the nearest whole number. So  $9.662 \text{ trees} \approx 10 \text{ trees}$  Therefore, at \$12 dollars per tree, we have:  $(10)(\$12) = \$120$

### 3 Dimensional Analysis

Unit fractions are the tools we use to convert between units on different scales of measurement. For instance, if we are told that one pole vaulter jumped 92 inches and another jumped 8 feet, we would have to convert both answers to either all feet or inches to compare them. The unit fraction that will help us with this comparison comes from the equation:

$$12 \text{ inches} = 1 \text{ foot}$$

If we divide both sides by 12 inches, we get:

$$1 = \frac{1 \text{ foot}}{12 \text{ inches}}$$

If we divide both sides by 1 foot, we get:

$$\frac{12 \text{ inches}}{1 \text{ foot}} = 1$$

We say that  $\frac{1 \text{ foot}}{12 \text{ inches}}$  and  $\frac{12 \text{ inches}}{1 \text{ foot}}$  are unit fractions because they are both equal to one. Now we proceed to example.

**Example:** Which is the best unit fraction to use if we want to convert 92 inches to feet? We see that:

$$\frac{92 \text{ inches}}{1} \times \frac{1 \text{ foot}}{12 \text{ inches}} \approx 7.66 \text{ feet}$$

Notice that in this example the word *inches* cancels.

If we wanted to convert 8 feet to inches, we would use the other unit fraction:

$$\frac{8 \text{ foot}}{1} \times \frac{12 \text{ inches}}{1 \text{ foot}} \approx 96 \text{ inches}$$

Notice that in this example the word *foot* cancels. Whenever we use unit fractions to convert from one set of units to another the process is called *dimensional analysis*. From the above discussion, we have several relationships and, hence, a set of associated unit fractions:

$12,000 \text{ mi} \approx 3.28 \text{ tons CO}_2$	$\frac{12,000 \text{ mi}}{3.28 \text{ tons CO}_2}$	$\frac{3.28 \text{ tons CO}_2}{12,000 \text{ mi}}$
$1 \text{ ton CO}_2 = 3700 \text{ mi}$	$\frac{3700 \text{ mi}}{1 \text{ ton CO}_2}$	$\frac{1 \text{ ton CO}_2}{3700 \text{ mi}}$
$1 \text{ tree} = \$12$	$\frac{1 \text{ tree}}{\$12}$	$\frac{\$12}{1 \text{ tree}}$
$12000 \text{ mi} = \$120$	$\frac{12000 \text{ mi}}{\$120}$	$\frac{\$120}{12000 \text{ mi}}$

**How much does it cost to erase a ton of Carbon?:** An interesting question is how do we standardized a carbon credit. One way to do it is to calculate how much it would cost to sequester 1 ton of carbon by reforestation based on a 30 mpg car. We will use the following equations and their associated unit fractions to convert to dollars per ton of CO<sub>2</sub> by reforestation:

$$12000 \text{ mi} = \$120$$

$$1 \text{ ton CO}_2 = 3700 \text{ mi}$$

**Solution:**

$$\left(\frac{\$120}{12000 \text{ mi}}\right)\left(\frac{3700 \text{ mi}}{1 \text{ ton}}\right) = \frac{\$37}{\text{ton}}$$

If we calculate exactly how much CO<sub>2</sub> one gallon of gasoline produces, we can compare the amounts of CO<sub>2</sub> different vehicles are responsible for. Burning 1 gallon of gasoline produces 0.00821 tons of CO<sub>2</sub>. Now we have the relationship:

$$1 \text{ gallon} = 0.00821 \text{ tons CO}_2$$

The associated unit fractions are:

$$\frac{1 \text{ gallon}}{0.00821 \text{ tons CO}_2}; \frac{0.00821 \text{ tons CO}_2}{1 \text{ gallon}}$$

In the next exercise, we will use the following statistics about vehicle makes and models to answer some questions

Make Model	Tank Cap.	Hwy. Mi.	No. Cyl.
Cadillac Escalade	22 g	19 mpg	8
Hummer H2	32 g	19 mpg	8
Accord Lx	17.1 g	29 mpg	6
Accord Ex	17.1 g	34 mpg	4
Accord Hybrid	17.1 g	35 mpg	4
Prius Hybrid	15 g	51 mpg	4
Your car	? g	? mpg	?

**Exercise:** Complete the information in the table based on the following questions.

1. If the car is driven 12,000 miles per year, how many gallons of gas are used?
2. If the car is driven 12,000 miles per year, how many tons of  $\text{CO}_2$  does the car emit?
3. If the car is driven 12,000 miles per year, how much will it cost to sequester its  $\text{CO}_2$  emissions by reforestation ?
4. If the gasoline tank on this car is filled three times per week for a year, how much gasoline is used?
5. If the gasoline tank on this car is filled three times per week for a year, how many miles are driven?
6. If the gasoline tank on this car is filled three times per week for a year, how many tons of  $\text{CO}_2$  does this vehicle produce?
7. If the gasoline tank on this car is filled three times per week for a year, how much will it cost to sequester its  $\text{CO}_2$  emissions by reforestation ?

*Complete the following table using the above information and the relevant unit fractions in this discussion. No calculators are allowed.*

Make Model	Q1.	Q2	Q3.	Q4.	Q5.	Q6.	Q7
Cadillac Escalade							
Hummer H2							
Accord Lx							
Accord Ex							
Accord Hybrid							
Prius Hybrid							
Your car							

1. Make a bar graph for each question listing the make and model of the vehicle on the horizontal axis.
2. Find the rate of fuel consumption for the Cadillac Escalade v. the Toyota Prius for 12,000 miles of driving.
3. Find the rate of  $\text{CO}_2$  for the Cadillac Escalade v. the Toyota Prius for 12,000 miles of driving.
4. Find the rate of fuel consumption for the Cadillac Escalade v. the Toyota Prius for tank refills 3 times per week for one year.
5. Find the rate of  $\text{CO}_2$  for the Cadillac Escalade v. the Toyota Prius for for tank refills 3 times per week for one year.
6. Make a bar graph for questions 2-5.

7. Write down one observation for each of the bar graphs for questions 1-5.
8. Now that you have completed this exercise, write three paragraphs on your opinion about each American's responsibility for his or her own CO<sub>2</sub> emissions.

## 4 Resources

<http://www.carbonfund.org/site/>

<http://www.carbonbankusa.com/>

<http://www.gocarbonfree.com/>

<http://www.carbonplanet.com/home/>