SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Be efficient	Grade 5 and 6
Fuel Consumption Answers	

The term efficiency or being efficient can be applied in different contexts. By definition, according to the dictionary, when something is efficient it is productive of desired effects. Especially capable of producing desired results with little to no waste (as of time or materials). We'll take a look at some of the different ways we can think of efficiency to expand on this concept and do some calculations.

Fuel efficiency: We hear about this when we talk about vehicles but it can apply to any fuel not just gasoline for our cars and trucks. It all comes down to the amount of chemical energy that is contained in a fuel that can be converted to useful energy or work. Energy cannot be created or destroyed, it can only be transferred and transformed. When we convert energy from one form to another, we often have what we call 'loss'. This is energy that is transferred or transformed into energy other than work. The most efficient fuel has the least loss. It transfers and transforms the most energy into a useful form. If we had an inefficient fuel, it would have more loss and less useful energy transfer.

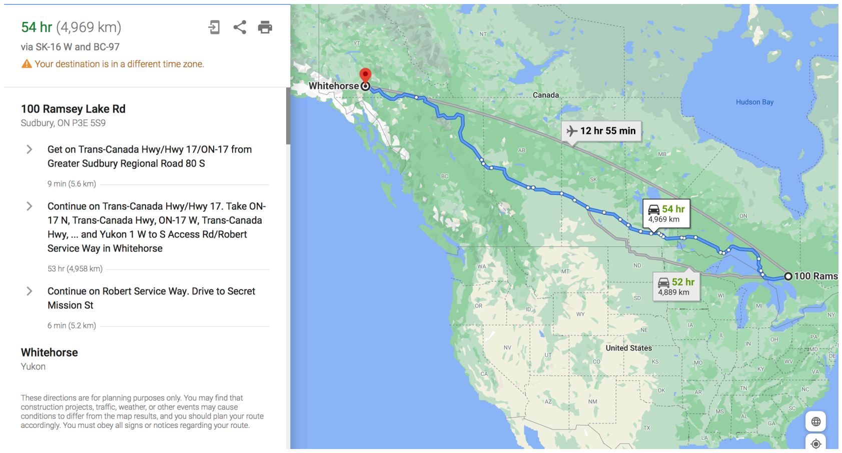
Fuel economy: This is the efficiency of a given vehicle. The fuel we use in vehicles has a certain efficiency. When we put that fuel into different systems or vehicles, the amount of useful energy we get out changes. There are many different elements that affect the fuel economy in vehicles like its size, engine, transmission, tires etc..

Fuel consumption: Sometimes we measure the useful energy as a distance travelled and compare that to the amount of fuel consumed by a vehicle to get there. That means we give a number of litres of per 100km. On average, how many litres of fuel does it take a given vehicle to travel 100km? When people are buying a new vehicle, this (L/100km) is a number that they can look up for a given make and model and can influence their purchase choice. Let's take a look at fuel consumption for different vehicles so we can estimate what the cost difference in fuel would be on a long trip. Fuel consumption is different and reported that way for City and Highway driving. We've used the combined City/Highway average fuel consumptions here.

www.nrcan.gc.ca/sites/nrcan/files/oee/pdf/transportation/tools/fuelratings/2020%20Fuel%20Consumption%20Guide.pdf

Vehicle Make and Model	*Fuel Consumption*
Car - Toyota Corolla	7.1 L/100km
Car - Mini Cooper 3 door	7.5 L/100km
Car - Lamborghini Aventador	21.4 L/100km
Truck - Ford F-150	10.6 L/100 km
Truck - GMC Sierra	11.1 L/100km
SUV - Chevrolet Suburban	13.4 L/100km
SUV - Hyundai Santa Fe	9.6 L/100km

The trip: From Science North, Sudbury, Ontario to Whitehorse, Yukon and back



We don't want to bring our passports so we will pick the route that stays in Canada. According to the route search, to go one way, it will be 4 969km. How far will it be for the round trip? ***9 938km*** *Since this calculation exercise is already an estimation, let's say the distance is an even 10 000km to make our future calculations a bit easier.

First, we'll need to take the fuel consumption data and multiply it by our final distance to see how many L of fuel we will require for the trip. Your formula will look like this:

Fuel Consumption in L/100 km * Distance to travel in km = L of fuel required

Vehicle Make and Model	***Fuel Consumption***	***Distance to travel****	***L of fuel required***
Car - Toyota Yaris	6.6 L/100 km	10 000 km	660 L
Car - Mini Cooper 3 door	7.5 L/100 km	10 000 km	750 L
Car - Lamborghini Aventador	21.4 L/100 km	10 000 km	2 140 L
Truck - Ford F-150	10.6 L/100 km	10 000 km	1 060 L
Truck - GMC Sierra	11.1 L/100 km	10 000 km	1 110 L
SUV - Chevrolet Suburban	13.4 L/100 km	10 000 km	1 340 L
SUV - Hyundai Santa Fe	9.6 L/100 km	10 000 km	960 L

Here's an example of the calculation for a Toyota Corolla to travel one way from Sudbury, ON to Timmins, ON approximately 300km:

$$\frac{7.1L}{100km} * 300km = 21.3L \qquad \text{OR} \qquad \frac{7.1L*300km}{100km} = 21.3L$$

Now that we know how many litres of fuel we will need for the trip; we can look up the cost of fuel per litre. **Gas prices will vary based on location but since this is a cross Canada trip, we'll take the national average for today (106.4¢/L) from www.caa.ca/gas-prices/. Remember: Gas prices are listed in cents per litre. If we want a cost in dollars, we'll need to add a conversion factor.

Your formula will look like this:

L of fuel required * Gas Price in cents/L * Dollar Conversion = Total Fuel Cost

Vehicle Make and Model	*L of fuel required*	*Gas price***	*Total Fuel Cost*
Car - Toyota Yaris	660 L	106.4¢/L	702.24$
Car - Mini Cooper 3 door	750 L	106.4¢/L	798.00$
Car - Lamborghini Aventador	2 140 L	106.4¢/L	2,276.96$
Truck - Ford F-150	1 060 L	106.4¢/L	1,127.84$
Truck - GMC Sierra	1 110 L	106.4¢/L	1,181.04$
SUV - Chevrolet Suburban	1 340 L	106.4¢/L	1,425.76$
SUV - Hyundai Santa Fe	960 L	106.4¢/L	1,021.44$

Here's an example of the total fuel cost for that trip in a Toyota Corolla from Sudbury to Timmins but since I am filling up in Sudbury, I'll use the price of gas from nearby instead (www.gasbuddy.com/gasprices/ontario/sudbury) and round to the nearest cent:

$$21.3L * \frac{109.6¢}{L} * \frac{1\$}{100¢} = 23.34\$ \qquad \text{OR} \qquad \frac{21.3L * 109.6¢ * 1\$}{L * 100¢} = 23.34\$$$

In a calculator, it looks like this: 21.3 x 109.6 ÷ 100 = 23.3448

There are other costs that aren't monetary for vehicles that don't have good fuel economy. Those are environmental. Carbon dioxide is a by-product of fuel consumption. We know that human driven carbon dioxide emissions contribute to climate change. On average, for each litre of fuel burned, 2.3kg of CO2 is produced.

www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/fuel-efficient-technologies/autosmart_factsheet_6_e.pdf

On this trip, how much more CO_2 does the vehicle with the worst fuel economy contribute to the environment than the one with best fuel economy?

Vehicle Make and Model	*L of fuel required*	*Emissions per L*	*CO_2 emissions*
Best - Toyota Yaris	660 L	2.3kg/L	1 518kg
Worst – Lamborghini Aventador	2 140L	2.3kg/L	4 922kg

Since we are asked how much more, we'll need to find the difference between the two numbers by doing a subtraction.

Worst CO_2 emissions – best CO_2 emissions = how much more emissions

The Lamborghini contributes 3 404kg more CO_2 to the atmosphere than the Toyota.

What can we say about the cost of the trip? If we only consider fuel economy, the cheapest vehicle listed is the Toyota Yaris. There could be other factors at play however that change the considerations. What we have calculated is a per vehicle cost, but we haven't discussed how many passengers or what cargo we need to bring.

1A) If the Mini Cooper transports 2 people for the trip and the Suburban transports 8 people, does that affect how we compare them?

Yes and no. The vehicles' efficiency as a machine is not affected but the cost and emissions efficiency is different if we consider per person rather than per vehicle.

B) How much fuel would be required for 4 Mini Coopers to transport 8 people for the length of the trip?

4 * 750L = 3000L
4 Mini Coopers would require 3000L of fuel.

C) How does that compare to the Suburban fuel requirements for the trip?

3 000L - 1 340L = 1 660L
4 Mini Coopers with 2 people each would use 1660L more fuel than 1 Suburban with 8 people.

2A) By extension, what can we say about public transportation? If a bus carries 50 passengers, who would have travelled in pairs, how many vehicles are 'taken off the road'?

50 passengers travelling in pairs would make 25 vehicles. If all those people get into a bus, that will count as 1 vehicle on the road. We can say that the bus took 24 vehicles off the road.

B) If we took that many Yaris' off the trip to the Yukon, how much fuel is saved?

24 * 660L = 15 840L
The fuel of 24 Yaris' not on the road to the Yukon is 15 840L.

C) How many kg of CO_2 are saved in that scenario? Count the 24 Yaris' off the road, you can ignore the bus emissions.

2.3kg/L * 15 840L = 36 432kg of CO_2