How do you get to work?

By CAR

To calculate the energy used by a car we can make use of the following formula (taken from SEWTHA):

$$energy = \frac{distance\ travelled}{distance\ per\ unit\ of\ fuel} \cdot energy\ per\ unit\ fuel$$

The "distance per unit of fuel" depends on the fuel consumption of the car, the way of driving etc. For Luxembourg, where the majority of the cars are "bigger" cars, we can assume safely assume a fuel consumption of 11 liters/100 km. Additionally, as Luxembourg is one big traffic jam, the constant Start&Stop leads to a larger fuel consumption that can be larger up to 170% (see ref. 1). We can conservatively assume 130% fuel consumption because we are not constantly in a traffic jam (I personally believe we can go closer to 170% but 130% seems conservative enough). Thus we would have a fuel consumption of 14.3 liters /100 km which translates into a reach of 7 km per liter of fuel.

As for the "energy per unit fuel", the SEWTHA indicates 10 kWh per liter of petrol and 11 kWh per liter of Diesel. Let's take the average i.e. 10.5 kWh per liter of fuel. So the above equation becomes:

$$energy = \ distance\ travelled \cdot \frac{10.5\ kWh/l}{7\ km/l}$$

$$energy = \ distance\ travelled \cdot \ 1.5\ kWh/km$$

If we also consider the amount of people inside the car *n*, then we end up with the final formula:

$$E = 1.5 \cdot \frac{D}{n} \cdot 2$$

where *D* is the distance in km. The unit of *E* would then be kWh/d/p (because the distance is per day). The factor of 2 at the end is for the roundtrip (to work and back home).

Ref. 1: http://www.verkehrsinitiative-hagnau.de/files/2017-02/p1-schadstoff-emissionen-verkehrsfluss-pr-s-2017-02-22x.pdf

By BUS

Passengers have a fuel consumption of about 40 liters per 100 km. Again, if we assume a 130% larger consumption due to rush-hour Start&Stop, we get a fuel consumption of 52 liters per 100km that translates into a reach of 1.9 km per liter. Thus, the energy needed to drive the bus with only the driver present is:

$$E = distance \ \cdot \frac{10.5 \frac{kWh}{l}}{1.9 \frac{km}{l}} = distance \cdot \ 5.5\ kWh/km$$

Using a modern bus as an example (Mercedes-Benz O 530 Citaro), which has a capacity of 158 persons (according to wiki), the energy used by a bus – assuming that it is full – is:

$$E = 0.03 \cdot D \cdot 2$$

where D is the distance. Unit of E is kWh/d/p. The factor of 2 at the end is for the roundtrip (to work and back home).

By TRAIN

The SEWTHA uses the value of 3 kWh per 100 km for an electric train, and 9 kWh per 100 km for a Diesel train (both assumed fully occupied). In any case, for the manuscript we can use the 3 kWh per 100 km. In terms of distance, this would be:

$$E = 0.03 \cdot D \cdot 2$$

in units of kWh/d/p. The factor of 2 at the end is for the roundtrip (to work and back home).