Calculation of GHG Emissions in the Selected Air Traffic Company

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Abstract. The paper is dedicated to calculating and declaring energy consumption and greenhouse gas emissions in an automotive component manufacturing company. The calculation was carried out on the bases of EN 16258. By this Directive, it is set out a procedure for determining the energy consumption and greenhouse gas emissions from transport services of all transport sectors.

1 Introduction

In today's ever-growing economic times, demands for speed and quality of service are increasing. Road transport is one of the most evolving transport industries. This is especially because it is capable of securing transport from company to company.

However, recently, mainly thanks to speed, air transport has been widely used. With the increasing interest of the population in the environment, there has been an increase in interest in the influence of greenhouse gases produced by transport. This paper will be dedicated to the calculation of aviation greenhouse gas emissions in the selected company.

2 Parameters specification

The selected company is engaged in manufacturing components for automotive. In most cases, the company secures transportation of components by the road freight transport. However, there are also exceptions where it is necessary to transport the material faster. For this shipment, it was selected the air transport [1-3].

For selected transport, the starting point is Ceske Budejovice and the target point is Stuttgart. The weight of transported material is 800 kg. The carriage will be carried out in the following way [4, 5]:

- from the company in Ceske Budejovice to the Ceske Budejovice Airport, the material will be transported by road vehicle, namely Renault Vivaro with a consumption of 6.2 liters (diesel) per 100 kilometres,

- from the Ceske Budejovice Airport to the Stuttgart Airport, the material will be transported by airplane, namely the Dornier DO 228 turboprop airplane with a consumption of 117 liters per 100 kilometers,

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- from the Stuttgart Airport to company in Stuttgart, the material will be transported by road vehicle, namely Volkswagen Transporter with a consumption of 5.9 liters (diesel) per 100 kilometers.

Figure 1 shows a schematic diagram of the material transport, which will be the basis for partial calculations f GHG emissions.

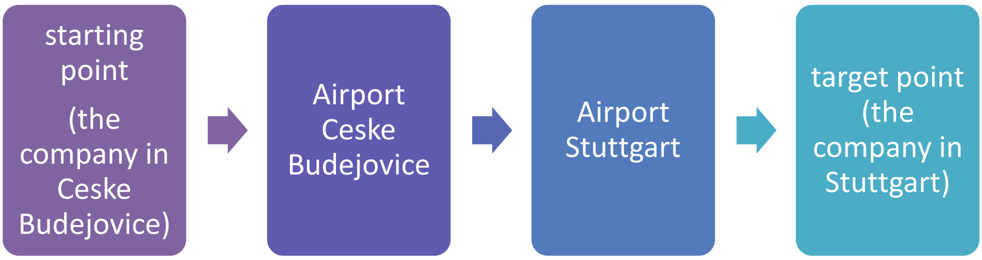

Fig. 1. Scheme of transport. Source: authors

The distance between company in Ceske Budejovice and Ceske Budejovice Airport is 8.5 km. Diesel fuel is used fuel. This section will be served by road transport. Subsequently, the material will be transported by airplane from Ceske Budejovice to Stuttgart.

The distance between Ceske Budejovice Airport and Stuttgart Airport is 388 km. The aviation kerosene Jet A1 is used fuel. After landing the airplane, the material will be transported by a road vehicle to the company in Stuttgart. The distance between the airport and the company is 21.2 km. This vehicle uses biodiesel fuel with 6% bio-fuel.

Table 1. Parameters specification. Source: authors

From	To	Distance	Used fuel
Company in Ceske Budejovice	Ceske Budejovice Airport	8.5 km	diesel
Ceske Budejovice Airport	Stuttgart Airport	388 km	aviation kerosene Jet A1
Stuttgart Airport	Company in Stuttgart	21.2 km	biodiesel

3 Calculation

The calculation will be realized on the base of the Methodology of calculation and declaration of energy consumption and greenhouse gas emissions from transport services for passenger and freight transport - STN EN 16258. STN EN 16258 is the Slovak version of the European Standard. This Standard sets out the procedure for calculating the energy and emissions declarations for transport services, regardless of their complexity [6-9].

Steps to calculating the energy consumption and greenhouse gas emissions from one transport service are as follows [2, 3, 10-12]:

- 1. step - identification different sections of the transport service,
- 2. step - calculation energy consumption and greenhouse gas emissions from each section,
- 3. step - The sum of the results that was determined for each section.

The calculation of the total energy consumption and greenhouse gases emissions is carried out according to the following formula:

- well-to-wheels for energy consumption VOS:

$$E_w(VOS) = F(VOS) * e_w \quad (1)$$

- well-to-wheels for greenhouse gases emissions VOS:

$$G_w(VOS) = F(VOS) * g_w \quad (2)$$

- tank-to-wheels for energy consumption VOS:

$$E_t(VOS) = F(VOS) * e_t \quad (3)$$

- tank-to-wheels for greenhouse gases emissions VOS:

$$G_t(VOS) = F(VOS) * g_t \quad (4)$$

Where:
- *F(VOS)* is the total fuel consumption used for the VOS transport section,
- e_w is well-to-wheels energy factor for used fuel,
- g_w is well-to-wheels greenhouse gas factor for used fuel,
- e_t is tank-to-wheels energy factor for used fuel,
- g_t is tank-to-wheels greenhouse gas factor for the fuel used.

For the first section, the following parameters are set:
- distance is 8.5 km,
- used fuel is a diesel fuel free of biofuel,
- consumption is 6.2 l per 100km.

The procedure of calculation will be as follows:

Table 2. Factors of diesel fuel free of biofuel. Source: EN16258

		Energy factor				**Greenhouse gas emission factor**					
		Tank-to-wheels (e_t)		**Well-to-whees(e_w)**		**Tank-to-wheels (g_t)**			**Well-to-wheels (g_w)**		
fuel type	**density (d)**	MJ/kg	MJ/l	MJ/kg	MJ/l	gCO2e/MJ	kgCO2e/kg	kgCO2e/l	gCO2e/MJ	kgCO2e/kg	kgCO2e/l
diesel fuel free of biofuel	0.832	43.1	35.9	51.3	42.7	74.5	3.21	2.67	90.4	3.9	3.24

$$E_w(VOS) = F(VOS) * e_w = 0.527 \times 42.7 = 22.5029\ MJ$$

$$G_w(VOS) = F(VOS) * g_w = 0.527 \times 3.24 = 1.7075\ kgCO_2e$$

$$E_t(VOS) = F(VOS) * e_t = 0.527 \times 35.9 = 19.9193\ MJ$$

$$G_t(VOS) = F(VOS) * g_t = 0.527 \times 2.67 = 1.4071\ kgCO_2e$$

The value for leg is as follows:

$$E_w(leg) = 22.5029\ MJ$$

$$G_w(leg) = 1.7075\ kgCO_2e$$

$$E_t(leg) = 18.9193\ MJ$$

$$G_t(leg) = 1.4071\ kgCO_2e$$

For the second section, the following parameters are set:
- distance is 388 km but it is still necessary to add 95 km based on the methodology, (total 483 km),
- used transport means is Dornier DO 228 turboprop,
- used fuel is an aviation kerosene Jet A1,
- consumption is 565,11 l per 100 km.

Table 3. Factors for aviation kerosene Jet A1. Source: EN16258

fuel type	density (d)	Energy factor				Greenhouse gas emission factor					
		Tank-to-wheels (e_t)		Well-to-whees(e_w)		Tank-to-wheels (e_t)			Well-to-whees(e_w)		
		MJ/kg	MJ/l	MJ/kg	MJ/l	gCO2e/MJ	kgCO2e/kg	kgCO2e/l	gCO2e/MJ	kgCO2e/kg	kgCO2e/l
aviation kerosene Jet A1	0.800	44.1	35.3	52.5	42	72.1	3.18	2.54	88	3.88	3.10

$$E_w(VOS) = F(VOS) * e_w = 565.11 \times 42 = 23734.62\ MJ$$

$$G_w(VOS) = F(VOS) * g_w = 565.11 \times 3.10 = 1751.841 kgCO_2e$$

$$E_t(VOS) = F(VOS) * e_t = 565.11 \times 35.3 = 19948.383\ MJ$$

$$G_t(VOS) = F(VOS) * g_t = 535.11 \times 2.54 = 1435.3794 kgCO_2e$$

The value for leg is as follows:

$$E_w(leg) = 23734.62\ MJ$$

$$G_w(leg) = 1751.841\ kgCO_2e$$

$$E_t(leg) = 19948.383\ MJ$$

$$G_t(leg) = 1435.3764\ kgCO_2e$$

For the third section, the following parameters are set:
- distance is 21.2 km,
- used fuel is a 6% biodiesel,
- consumption is 1.2508 l for this section.

Table 4. Factors of 6% biodiesel. Source: EN16258

fuel type	density (d)	Energy factor				Greenhouse gas emission factor					
		Tank-to-wheels (e_t)		Well-to-whees(e_w)		Tank-to-wheels (e_t)			Well-to-whees(e_w)		
		MJ/kg	MJ/l	MJ/kg	MJ/l	gCO2e/MJ	kgCO2e/kg	kgCO2e/l	gCO2e/MJ	kgCO2e/kg	kgCO2e/l
6% biodiesel	0.83548	42.7	35.7	53	44.2	70.3	3	2.51	88.5	3.78	3.16

$$E_w(VOS) = F(VOS) * e_w = 1.2508 \times 44.2 = 55.2854\ MJ$$

$$G_w(VOS) = F(VOS) * g_w = 1.2508 \times 3.16 = 3.9525\ kgCO_2e$$

$$E_t(VOS) = F(VOS) * e_t = 1.2508 \times 35.7 = 44.6536\ MJ$$

$$G_t(VOS) = F(VOS) * g_t = 1.2508 \times 2.51 = 3.1395\ kgCO_2e$$

The value for leg is as follows:

$$E_w(leg) = 55.2854\ MJ$$

$$G_w(leg) = 3.3525\ kgCO_2e$$

$$E_t(leg) = 44.6536\ MJ$$

$$G_t(leg) = 3.1395\ kgCO_2e$$

The following table shows partial results from the previous steps. This table shows the outputs from individual transport sections. These sections include the transport of 800 kg of material from Ceske Budejovice to Stuttgart. The last row of table contains the totals of sub-items.

Table 5. Partial results recapitulation. Source: authors

Transport service	E_w (leg) [MJ]	G_w (leg) [kgCO_2e]	E_t (leg) [MJ]	G_t (leg) [kgCO_2e]
VOS(leg) 1	22.5029	1.7075	19.9193	1.4071
VOS(leg) 2	23734.62	1751.841	19948.383	1435.3794
VOS(leg) 3	55.2854	3.9525	44.6536	3.1395
Total	**23812.407**	**1757.501**	**20011.955**	**1439.926**

The total energy consumption and greenhouse gas emissions production for transport of material with weight 800kg by air transport is as follows:

$$E_w(leg) = 23812.407\ MJ$$

$$G_w(leg) = 1757.501\ kgCO_2e$$

$$E_t(leg) = 20011.955\ MJ$$

$$G_t(leg) = 1439.926\ kgCO_2e$$

4 Conclusion

On the basis of the analyzed information, the calculation of the energy consumption and the greenhouse gas emissions production was realized for the automotive component manufacturing company. The company uses mainly freight transport for the transport of its products. In some cases, when it is necessery to transport the components to the company's as soon as, it is necessary to use the air transport.

The company has applied environmental standards in corporate culture rules. Its primary objective is to contribute to improving the environment. For this reason, the calculation of the above-mentioned transport task was demanded.

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