Sustainability Report

2015

This report describes the Well-to-Wheels (WTW) emissions for the University of Idaho 2015 FHSAE vehicle. This includes an overall assessment of CO_2 emitted per unit distance covered during the endurance event. This calculation takes into account Well to Tank (WTT) emissions, and the Tank to Wheels (TTW) emissions. The report presented also includes the CO_2 emissions from the generation of electricity needed to charge the high voltage system. Calculations track the emissions of the refinement, transportation of fuels and include the vehicle fuel efficiency to provide a fairly comprehensive representation of CO_2 emissions.

The Well-to-Tank (WTT) component of WTW emissions accounts for CO_2 generated during the process of extraction, production, transportation, and distribution of the fuel. Assuming perfect combustion, all the carbon eventually produces CO_2. Since crude oil has a carbon content of 19.9 [g/MJ][1], and each gram of carbon outputs 3.67 grams of CO_2. Then, the CO_2 content of the crude oil is calculated as: 19.9 [g/MJ] * 3.67 = 73.0 [gCO_2/MJ]. Knowing that fuel production and transportation to the gas station is 81.7%[2] efficient, 18.3% of the energy content of the crude oil is lost to production and transportation. As such, 13.36 [gCO_2/MJ) accounts for WTT losses.

The Tank-to-Wheels (TTW) evaluation accounts for the CO_2 emitted by the vehicle/fuel combination includes both evaporative and combustion emissions. Evaporative emissions occur when fuel leaks or evaporates from the fuel storage tank and delivery system. This report assumes for this report perfect isolation of the fuel system, neglecting the evaporative losses in the system. While CO_2 emissions from combustion are calculated directly from the carbon content of the fuel used in the vehicle. The approach used for calculating the CO_2 emissions from the combustions process is found in Table 5-1[3]. To calculate the combustion portion of the TTW for one km of the endurance race, a GT-Suite[4] model for the previously designed vehicle is used. This model includes a map based engine model of the YZ250F, a performance map for the traction motor, and a road load model to simulate track performance and energy usage. These models were also backed up with test data in the form of fuel economy, and rolling resistance data.

Given gasoline's energy content of 34.2 [MJ/liter], or 129.618 [MJ/gal], and fuel consumption of 29 [mpg] the combustion portion of the TTW can be calculated as such;

$$\therefore \text{ vehicle energy consumption} = \frac{\text{Fuel energy content}}{\text{Fuel consumption}}$$

$$= \frac{129.618\left[\frac{MJ}{gal}\right]}{29\ [mpg]} = 4.4696\left[\frac{MJ}{mile}\right] = 2.777\left[\frac{MJ}{km}\right]$$

While the $CO_2\left[\frac{\text{g}}{\text{mile}}\right] =$

$$\text{carbon factor}\left[\frac{\text{gCO2}}{\text{MJ}}\right] * Vehicle\ energy\ cons.\left[\frac{MJ}{mile}\right]$$

$$\therefore \text{ g } CO_2\text{ /km} = 59.64 * \frac{4.4696}{1.6093} = 165.637\ [\text{g } CO_2\text{/km}]$$

The information from the U.S. Energy Information Administration is used in calculating the emissions for the electric generation[5] to account for the energy needed to charge the battery pack used on the vehicle. The CO_2 emissions for mixed electricity production are found to be 168.1 [gCO_2/MJ]. Next calculations are needed to find the efficiency losses of the electrical system to determine the total needed power input to produce one MJ of power output at the wheels. Out of the 35.5 MJ of energy initial stored on board, 2 MJ is contained in the battery pack. Both resources are expected to be fully used during the endurance event. The CO_2 generation associated with electrical energy use from the grid is therefore 7.56 gCO_2/MJ. The average rate of electrical energy consumption to propel the vehicle over the 44 km endurance course is .045 MJ/km. The CO_2 generation associated with a full battery pack is the CO_2 generated in fuel production multiplied by the electrical energy consumption. This results in a total CO_2 generation of 0.34 gCO_2/km because there is no direct CO_2 emission during electrical system operation.

	Fuel	**Electricity**
CO_2 generated in fuel production	13.36 [gCO_2/MJ]	7.56 [gCO_2/MJ]
Energy consumption	2.77 [MJ/km]	0.045[MJ/km]
CO_2 generated in fuel production/km	37.01 [gCO_2/km]	0.34 [gCO_2/km]
CO_2 generated during combustion/km	165.637 [gCO_2/km]	0 [gCO_2/km]
Total CO_2 generated	202.64 [gCO_2/km]	0.34 [gCO_2/km]

In order to ensure the vehicle is capable of meeting the necessary fuel economy to complete the endurance events several overall goals have been set for this development year. The first is the weight reduction of the vehicle, by reducing the overall weight the engine will have a lower load. With a smaller load the engine will require less fuel to achieve the same speed. The second goal set for the year is to recalibrate the engine itself. This engine has under gone extensive calibration to improve the efficiency of the system by bringing the air fuel ratios as close as possible to improve fuel economy and the overall combustion process. The third goal is the implementation of a dynamic control system that adjusts the power split of the hybrid system based upon feedback from the vehicle conditions. This allows the vehicle to use the most efficient system or to operate the systems at their individual efficacy points for increased overall fuel economy.

[1] https://bioenergy.ornl.gov/papers/misc/energy_conv.html

[2] Well-to-Tank Energy Use and Greenhouse Gas Emissions of Transportation Fuels – North American Analysis, June 2001, by GM, Argonne National Laboratory, BP, ExxonMobil, and Shell. Vol. 3, Page 59.

[3] California Energy Commission. Full Fuel Cycle Assessment - Tank to Wheels Emissions and Energy Consumption. Feb. 2007.

[4] https://www.gtisoft.com/

[5] http://www.eia.gov/