***PAPER***

***FUEL LIFE CYCLE ANALYSIS FOR DIFFERENT TYPES OF VEHICLES IN THE CANARY ISLANDS***

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## Overview

Nowadays, transport sectors is one of the highest energy demand worldwide, within road trasnportation is the one with the greatest weight in final energy consumption (approx. 21%). Moreover, the intensive use of fossil fuels in land transport produces a 17% of the total CO2 emissios according to the International Energy Agency [1]. In addition, energy consumption in this sector is growing considerably, especially in countries with developing economies [2]. The European Union (EU) has revealed its interest in this area, promoting new objectives for the reduction of CO2 emissions and promoting low or zero emission vehicles [3-5]. From technical point of view, improving vehicle consumption and minimizing the impacts of demand growth in the transport sector are crucial aspects to meet the objectives proposed by the EU. Thus, Internal Combustion Engine Vehicles, (ICEV) will dominate the market in the coming years. However, automakers are offering new solutions to reduce the emissions in short term period thoght alternative, such us, Liquefied Petroleum Gas (LPG) or hybrid electric vehicles (HEV) using different configurations. However, Plug-in Electric Vehicles (PEV) are emerging solution to reduce both energy consumption and greenhouse gas (GHG) emissions.

The need to implement road transportation alternatives is more urgent the greater the dependence on fossil fuels. The EU has placed special interest in the case of isolated regions, since they are not only more vulnerable to the effects of climate change, but also import the majority of resources (energy or not) they consume. The Canary Islands are a case study with various peculiarities, as they constitute the most populous region (over two million inhabitants) and with the highest GDP of the outermost regions of the EU [6]. From the energy perspective, however, the archipelago stands out for relying on almost 99% of fossil fuels as a primary energy source [7]. Due to the great external energy dependence and the use of petroleum derivatives in the production of electric energy, there is a debate about whether the electric vehicle is the best alternative to mitigate emissions in transport. Despite the existence of energy policies in favor of renewables [8], in recent years only 16% of renewable penetration has been achieved on average in the Canary Islands in the last 2019. This paper aims to evaluate the different technological alternatives of land transport in terms of energy consumption and GHG emissions. To achieve this, a methodology of the Well to the Wheel framed within the analysis of the life cycle of the fuel in transport will be used. Finally, we will evaluate a series of time scenarios (2020 and 2030), taking a database of more than 325 vehicles of different technologies and segments.

## Methods

This work uses a well-to-wheel methodology, widely developed in the literature. This consists of tracking the life cycle of the fuel from its extraction to its use in the vehicle to move it [9-13]. This methodology has several variants [14], [15], however, the scope of our study will evaluate the fuel cycle, thus not including the manufacture and subsequent second life of the vehicle or its parts. This methodology is usually expressed in two parts. The former, known as “well to the tank” or the plug (WtT or WtP), analyzes the consumption from the extraction of fuel to the energy storage inside the vehicle. The later, is composed of the vehicle's own use and its internal operation until its movement, known as “tank to wheels” or “plug to wheels” (TtW or PtW). Taking this methodology, it is an experiment of Monte Carlo for 1000 cases of consumption per vehicle (remember that the inventory is 325 different) and later, we will combine this simulation with the scenarios proposed for the different Canary Island systems in 2020 and an estimate for 2030. Data from all island electrical systems have been collected from 2013 to 2019 and it has been simulated that renewable penetration will be achieved in 2020 and 2030 taking into account the planning of the region. In addition, the origin of fossil fuels (countries of origin, distances, imported quantities and ships) has been compiled to simulate pathways for both conventional vehicles (diesel and gasoline) and PEVs.

## Results

The results are presented in two parts: conventional cars and PEVs. In the case of ICEVs the results of emisiones are the same in temporal scenarios. It means that we have assumed that 2020 car will pollutes aproximatelly the same emisiones year per year. For these vehicles the results are the following:

|  |  |
| --- | --- |
|  | WtW GHG emisions [g.CO2eq/km] |
| Gasoline cars | 265.59 |
| Diesel cars | 268.61 |
| LPG | 190.63 |
| HEVs | 197.79 |

In the case of PEVs we divided the results in two temporal periods: a) present scenario (2020) and b) future scenario (2030). For the first one the results of GHG emisions are presented as follows:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2020 | | | | | 2030 | | | |
| Scenario | TF-LG | GC | FV-LZ | LP | EH | TF-LG | GC- FV-LZ | LP | EH |
| Renewable [%] | 24% | 30% | 21% | 30% | 60% | 33% | 52% | 46% | 68% |
| BEVs | 140.27 | 121.12 | 146.64 | 137.03 | 71.28 | 119.17 | 95.35 | 100.05 | 56.86 |
| PHEVs | 215.94 | 195.30 | 222.82 | 212.42 | 141.63 | 193.22 | 167.57 | 172.61 | 126.13 |

## Conclusions

Road transportation is one of the most polloting sectors worldwide. To cope with the environmentat commintments, the goberments should boost policies focusing on altenative green solutions. In the Canary Islands the situation is critical due to the intense use of petroleum derivatives that has led to 98% energy dependence in 2018. Thus, the advantages of the PEVs as mitigator of equivalent emissions is partially lost. The results shows that the impact on the environment of PEVs depends significantly on how cleanest is or electricity production. Additionally, in some scenarios EVs could be similar pollutant than ICEVs. The alternative of Plug-in hybrids electric cars, its requires cleanest mixes (more than 25% of renewable energy in the mix) to improve the equivalent emissions of ICEVs. However it is important to note that PEVs does not pollute locally, reducing dangerous gases in cities. Finally, the BEVs becames the best solutions achieving reducions about 40% in CO2 in 2030 scenarios.

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