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Energy Reports 6 (2020) 315–321
www.elsevier.com/locate/egyr

The 6th International Conference on Power and Energy Systems Engineering (CPESE 2019), September 20–23, 2019, Okinawa, Japan

A case for the internal combustion engine powered vehicle

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Received 4 October 2019; accepted 22 November 2019

Abstract

The damaging effect of climate change has made mankind to continuously pursue means of reversing global warming caused by greenhouse gases. CO_2 gas according to available data for the year 2010 represents a whopping 76% of the emitted global greenhouse gases hence, making it a focal point in the reduction of greenhouse gases. Many nations are looking at the halt of the internal combustion engine powered vehicles and are making favourable policies for the adoption of electric vehicles to reduce the emission of greenhouse gas. This study reviews the contribution of the internal combustion engine powered vehicle to the global CO_2 gas emission, comparison of its CO_2 emission rate to that of the electric vehicle based on their life cycle assessment, and the health challenges that the disposal of the electric vehicle batteries can pose to human. The CO_2 emission rate of electric vehicles based on life cycle assessment is comparable to that of internal combustion engine vehicles power on gasoline and diesel, and based on emission per KWh of electricity generation in the UK, Germany, India, and China, the diesel powered internal combustion engine was observed to be better than that of the average electric vehicle based on a kilometer of road travel, asides the potential health risk which the subsequent disposal of batteries can cause. A great boost in the reduction of CO_2 emission can be made with the development of the commercial production and adoption of synthetic fuel for use with the conventional internal combustion engine vehicles.

Peer-review under responsibility of the scientific committee of the 6th International Conference on Power and Energy Systems Engineering (CPESE 2019).

Keywords: CO_2 emission; Electric vehicle; Global warming; Greenhouse gas; Internal combustion engine

1. Introduction

Greenhouse gases emit and absorbs energy within the thermal infrared range, and are composed primarily of CO_2, fluorinated gases, methane and nitrous oxides [1,2].

The combustion of fossil fuels is the primary contributor to the production of CO_2, although another contributor is the human-induced impact on forestry and land use [3] which is approximately a sixth of that release by fossil

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https://doi.org/10.1016/j.egyr.2019.11.082

Peer-review under responsibility of the scientific committee of the 6th International Conference on Power and Energy Systems Engineering (CPESE 2019).

fuel combustion [1]. Agricultural activities are the primary contributor to the production of nitrous oxides, and in combination with biomass combustion and waste management contributes to the generation of methane [1].

The largest chunk of greenhouse gas is due to CO_2 generation as it forms a whopping 76% of the global greenhouse gas emitted in 2010 [1,4] as depicted in Fig. 1, hence it is not out of place to find a drastic means of reducing it.

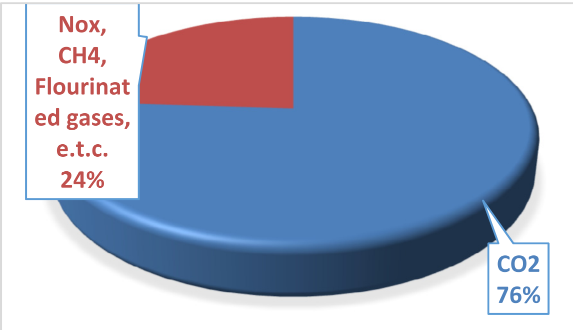

Fig. 1. Greenhouse gas emission generation by source in the year 2010.

It is, however, not to be taken that greenhouse gas production is bad in entirety, in reality, its production in moderation is very crucial to the survival of all creatures, human inclusive. It is the generation of an excess of it, which is detrimental to the environment causing global warming, moderate emission level is essential for the prevention of very low temperatures that cannot sustain live [2]. Over the years, global warming caused by greenhouse gas has led to an increase of about 0.87 °C from pre-industrial levels to the decade 2006–2015 [2,3,5], and even above 1.5 °C in some regions, but the good news is that if emissions level is brought low, past emissions are unlikely to raise the average global mean temperature above 1.5 °C [5].

2. Nations push to reduce greenhouse gas emission

Many nations government are formulating policies and offering incentives that favour the uptake of Electric vehicles as against the traditional internal combustion engines. Denmark places 180% tax rates on internal combustion engine powered vehicles [6], this is asides other incentives like free charging and city parking. Norway also does free charging and city parking, free tolls and bus lane access for Electric vehicles, a largesse which is not applicable to internal combustion powered vehicles, asides the waivers on vehicle registration tax and value added tax [7] and Chinese government enforces research, development and deployment of Electric vehicles and offers a whole lot of incentives to the populace [8]. Batteries for electric vehicles are now more powerful and relatively cheaper than before "Lambert [9]", basically due to improved technology and impetus of a more robust market.

There is the general belief that eradicating vehicles powered by the internal combustion engines will result into a drastic drop in the emission of CO_2 gas, as the perception about electric vehicles is that it is green and clean [10]. However, the contribution to greenhouse gas emissions by economic sector, as at 2010 puts the percentage contribution of the transport sector at about 14% coming after electricity and heat generation sector; 25%, agriculture, forestry and other land use; 24%, and industrial sector; 21% for direct emissions [4]. It is, however, imperative to note that not just automobiles make up the transport sector, it includes planes, ships, trains, and earth moving equipment. Studies conducted in the US place the emission of greenhouse gas from the transportation sector second to that of the electricity generation sector. However, it is worthy of note that CO_2 emissions related to fossil fuel combustion accounted for about 65% of the global CO_2 emission values in 2010 [4] and this is illustrated in Fig. 2.

China is at the forefront of nations calling for the disuse of internal combustion engine powered vehicles for the adoption of electric vehicles. It is not out of place for it as a nation to be a strong advocate for this, as a country, it contributes about 30% of the total global emission of CO_2 in 2014 [11,12], and it is the largest emitter of the gas [13]. China's manufacturing sector is the largest contributor to its CO_2 emission, showing a percentage increase of above 220% in 2015 over that of 1995 [13], and its transport sector as at 2012 accounted for just about 10% [11]. Statistics for the year 2015 shows that its manufacturing sector contributed a whopping 58% of its total CO_2

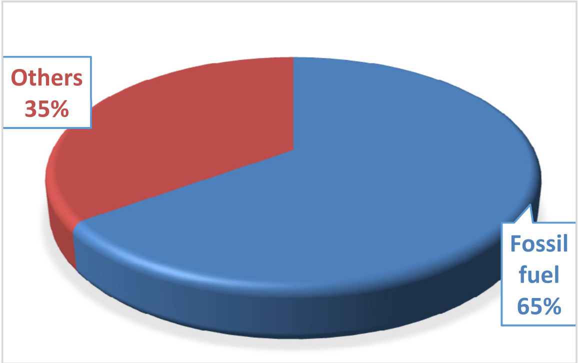

Fig. 2. Fossil fuel contribution to global CO_2 emission in 2010.

emission value and this is closely followed by the power sector [13]. Data available for Europe as at 2012 puts the percentage contribution of light-duty vehicles to the continent CO_2 emission at 15% [14]. This is as depicted in Fig. 3.

Working with the data of 25% of the global CO_2 emission [4] coming from power generation, the world moving to electric vehicles and facing out of internal combustion engine powered vehicles will put further pressure on power generation which will definitely result in increased CO_2 emission from the sector unless the additional required power will be generated only from green sources. Another school of thought will want to say, it will connote to the disappearance of the 14% coming from the transportation sector [4], however, we beg to disagree with this, because data for global energy generation sources for the year 2015 shows fossil fuels accounted for about 87% while renewable sources including nuclear and hydropower accounted for about 13% [15]. More than 66% of global electricity generation is based on Fossil fuels combustion in the year 2015 [15] as shown in Fig. 4, and data available for the year 2017 shows that the figures have remained basically unchanged with fossil fuel generated electricity value standing at 65% [16].

China is the world largest producer of electricity followed by the United States and India [17], over 75% of the electricity generation in China comes from fossil fuels in 2015, 72% of it being from Coal, and its projection for the year 2040 puts the expected dependence on fossil fuels above 50% [18] if things go according to plans. However, as at the year 2017, Coal stills accounts for 65% of her electricity generation, and for about 30% for that of the United States [19]. India produces about 79.4% of its electricity from fossil fuels with 67.9% from coal according to data available for the year 2011 [17]. It is interesting to note that the recent data released for the 2018 showed energy consumption reached a record high and fossil fuels accounted for about 80% of it in the United States in 2018 as a result of its growing economy demanding more electricity generation among others [20].

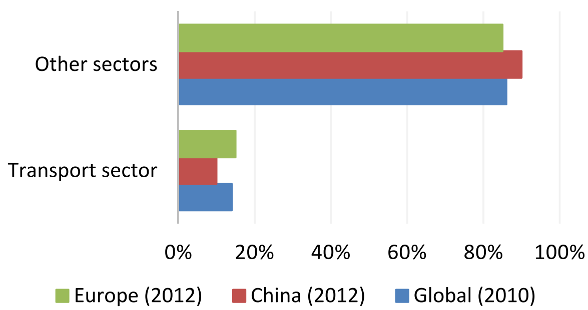

Fig. 3. Transport sector contributions to CO_2 emission.

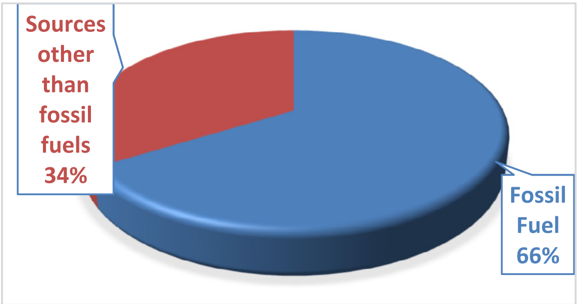

Fig. 4. Global electricity generation sources in 2015.

3. The pros and cons of electric vehicle usage

The sole adoption of the electric vehicle will mean more electricity generation, and looking at the top countries that could drive the production, China, United States, India, Russia, United Kingdom, and Germany will always come to mind, and all these countries rely mainly on fossil fuels for the generation of their electricity based on available data [17]. It is indisputable that the emission from electric vehicles will be much lesser than that of an internal combustion engine powered one if the electricity source is green [21]. However, with the available data on electricity generation sources, it is most likely that the emission from electric vehicles will be greater than that of the internal combustion engine powered vehicle when compared holistically [21], especially if it is the case that the electricity is generated from Coal. Generation of 1 Wh of energy from coal produces about 1.22 times amount of CO_2 emission in comparison to Oil [22], asides the fact that a Coal power plant have lower efficiency in comparison to thermal plants operated on Oil/diesel at a ratio of 1:1.4 [23], and in comparison to a compression ignition engine, the efficiency ratio is about 1:1.8 [24]. It will hence not be out of place to say that if the big nations highlighted above all adopt the use of electric vehicles, the CO_2 emission on a holistic consideration will definitely be the same as that of the internal combustion engine powered vehicles, as studies reveal that in view of today's energy mix, CO_2 emission from plug-in hybrids and electric vehicles comes very close to that of gasoline and diesel powered vehicles [25].

Some school of thought for the adoption of the electric vehicle over the internal combustion engine vehicles is also based on lower cost of maintenance, however, a study on the Tesla Model 3 shows that it cost more to in terms of per mileage to recharge it in comparison to the year 2018 model hybrid cars fuelled with gasoline produced by top automakers around the world [26].

The energy consumption per head in Africa is low [27], and most countries in the continent are finding it difficult to generate their required electric power, and hence depends on the internal combustion engine generators to meet part of the shortfall. Will it not then be an aberration to first generate the electricity to charge the electric vehicles from internal combustion engines and then come out to call that same vehicle green?

The electric vehicle's batteries till date are expected to be populated by the Lithium-ion cells which are basically composed of Graphite, Lithium salts, and other formulations of elements [8,28], because of its high energy and power density [29]. However, asides the health and safety issues associated with the use of Lithium and the other materials used in the Lithium-ion batteries, a big question asking for an answer is how the supply of the essential elements; Lithium, Cobalt, Nickel, and Graphite, required for the production of these batteries will be met.

Lithium is a highly reactive element like all alkali metals, and it cannot be found freely in nature [30]. It is produced commercially by recovery processes from brine which exists in Chile, and a prospective mine in Nevada.

Lithium-ion batteries produce CO_2 on thermal decomposition of the electrolyte, and it is the reduction of this gas and its subsequent formation that results in the batteries been able to store energy and prevent self-discharge [31]. Removal of CO_2 from the solution either due to escape or irreversible reduction results into power fade [31,32], an indication that one way or the other, either by accident or by intention during disposal, greenhouse gas "CO_2" is liberated. Studies show that about 12.5 kg of CO_2 equivalent is discharged by 1 kg of Lithium batteries nature [30]. The production of these batteries have also be said to have resulted in the production of CO_2 gas in the range of 90–200 kg CO_2 emission per kilogram evidenced from several studies undertaken by different scholars [33,34].

The Lithium-ion batteries powered electric vehicles will be subjected to temperatures which will be high enough to cause thermal decomposition of the electrolyte, and this will in return lead to the generation of highly toxic substances, however, the thermal decomposition is inhibited by the Lithium metal oxides [32]. Temperature increase during storage adds to the severity of irreversible capacity drop of Lithium-ion batteries [35]. Improper disposer of such batteries will, however, pose a serious environmental challenge when the electrolyte comes in contact with other materials as they are composed of hazardous materials [30,36,37]. Exposure to large dose of Lithium can also pose serious health challenges like renal toxicity, neurotoxicity, central nervous system toxicity, and gastrointestinal toxicity among others [30], Cobalt can lead to neurological syndrome, cardiovascular, and endocrine issues [38], while Nickel is also known to have damaging effects on immune, hepatic, pulmonary systems, are is said to be hepatotoxic, pulmotoxic, and nephrotoxic agent [39].

4. A case for the internal combustion engines

The advancement in the design of the internal combustion engines especially along the front of combustion chamber geometry and fuels have helped to further put it in good standing and assisted in the reduction of its emissions [40–42]. The use of dimethyl ether as a fuel in compression ignition engine powered vehicle results in the reduction of CO_2 emission [40]. A great deal of success recorded in emission reduction and performance optimization had made many researchers focus on this area to reducing the production of greenhouse gas from internal combustion engines.

The development of synthetic fuels has even brought a bigger boost to the internal combustion engine powered vehicles. It has been estimated that the use of synthetic fuels in our conventional internal combustion engines will be more green than for electric vehicles [25]. Based on the life cycle assessment over a lifespan mileage of 200,000 km, a gasoline vehicle emits 167 g, diesel vehicle does 134 g, the hybrid does 145 g, and an electric vehicle emits 114 g of CO_2 gas per kilometer. However, with the evolving technology of producing fuels which are compliant in usage in the internal combustion engines from CO_2, the internal combustion engines powered on such synthetic fuels are positively incomparable to the electric vehicles in terms of CO_2 emission, as only 34 g of the gas will be emitted per kilometre based on a mileage of 200, 000 km for the life cycle assessment [25], and further studies suggest it could be carbon neutral if the source of electricity used is green [43].

Based on available data from literature, the average internal combustion engine vehicle with petrol as fuel does 0.144 kg/km of CO_2, while if diesel as fuel does 0.109 kg/km of CO_2 [25] while on the road. The United Kingdom generates 1 KWh of electricity with CO_2 emission of 0.275 kg [44], Germany emits 0.596 kg of CO_2 for each KWh of electricity generated, India does an average of 0.93 kg of CO_2 for a KWh of generated electricity [45], while the figures for China in 2010 was 0.7212 kg of CO_2 for each KWh of electricity generation [46].

The average energy consumed by six different electric vehicles makers; BMW, Chevrolet, Ford, Hyundai, Nissan, and Tesla per kilometre stands at 0.182 KWh [47]. The CO_2 gas emission due to the on-road usage of the electric vehicle based on electricity generation for the UK, Germany, India, and China against that of the internal combustion engine vehicle is shown in Fig. 5

The amount of CO_2 gas emitted by the internal combustion engine vehicle can be seen to close to that emitted by the electric vehicle using the average of the electricity generation emission of the four cited countries, and in actual sense of it, it was lower for the diesel powered vehicle. The use of diesel powered internal combustion engine vehicles is greener than the use of electric vehicles for the case of India, and even China which has made stringent policies to stop the use of internal combustion engine vehicles in the nearest future.

5. Conclusion

The erroneous idea of saying that electric vehicles are free of greenhouse gas emission needs to be dealt away with as this study has shown that CO_2 emission values of these vehicles are close to that emitted by the much castigated internal combustion engines. Finding an alternative fuel to fossil fuels will in no doubt result in a drastic reduction of CO_2 emission, especially as it is being employed in electricity generation. Until electricity generation becomes green, the electric vehicle cannot be said to be green, the closer it moves towards green, the closer the electric vehicle will move towards green and vice versa. The contribution of the transportation sector to climatic change caused by the greenhouse gases can, however, be drastically reduced by the encouragement of further studies tailored towards the economical commercial production of synthetic fuels which can be used to power the internal combustion engines.

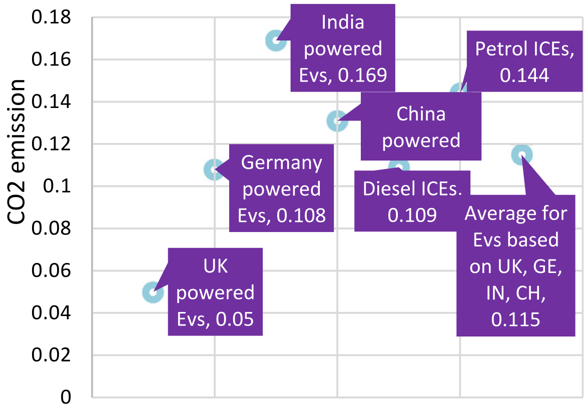

Fig. 5. CO_2 footprints of Electric vehicles powered in different countries and internal combustion engine vehicles.

Acknowledgement

The authors appreciate Covenant University, Ota, Nigeria for the funding of the APC.

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