

Health effect of emission from electric and biodiesel vehicles – A review

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ABSTRACT

The transport vehicles have been using the internal combustion engine for many decades. The internal combustion engine is used because of its high reliability. The transport sector plays a vital role in the country's economy. It is estimated that about 90% of the transportation sector uses fossil fuels. With the increasing industrialization, there will be a shortage of fossil fuels. Every year, there is an increase in the energy demand by 2%, stated by International Energy Agency Report. There would be 39% increase in the greenhouse gas emission by the year 2030 from fossil fuels. With the rising concern about climate change and the increasing amount of toxic emissions, manufacturers of the car are getting aware and are shifting towards less polluting vehicles or green vehicles. Biodiesel is also gaining interest and is being preferred because of its continued availability, emission characteristics showed that biodiesel has low CO emission. With addition of ethanol, the emission of CO further decreases, but NO_x emission increases. NO_x decreased with jatropha methyl ester and 50% turpentine oil. On the other hand, the use of electric vehicle or hybrid electric vehicle would also decrease the emission by 51% but would increase the load on power grid by 3% for every 30% penetration, which would increase the emission/air pollution from the thermal power plant. Emission in the human body can cause illness, increase the death, and be hazardous to the health of humans. This paper gives a review of the emissions from biodiesel and electric vehicles and the health effects.

Keywords: Electric vehicle; Bio-diesel; Health effect; NO_x; CO.

INTRODUCTION

The transport vehicles have been using the internal combustion engine for many decades. Internal combustion engine is used because of their high reliability. The transport sector plays a vital role in the country's economy. The transport fleet mainly uses fossil fuels for their working. The major use is petrol and diesel in the fleet. It is estimated that about 90% of the transportation sector uses fossil fuels. With the increasing industrialization, there will be a shortage of fossil fuels. The energy resources are less in amount, and accessibility to the resources is difficult. These fuels produce a lot of emissions. The emissions are CO, HC, NO_x, and greenhouse gases. Every year, there is an increase in the energy demand by 2%, stated by International Energy Agency Report (Aaron et al., 2018). There would be 39% increase in the greenhouse gas emission by the year 2030 from the fossil fuels (Kamalesh et al., 2015). The rising emission for the vehicles has made us think about the alternative fuels and hybridization of the vehicles.

There is an immense need to curb the fuel crisis. Fossil fuel emissions can lead to problems related to health and respiratory issue (asthma).

With the rising concern about climate change and the increasing amount of toxic emissions, manufacturers of the car are getting aware and are shifting towards less polluting vehicles or green vehicles. Hybrid and electric vehicles are green vehicles and alternate fuels. Japan was the first country to introduce a hybrid electric vehicle commercially. In the year 2015, the penetration of the hybrid electric vehicle in the Japanese houses was 9.8%, reported by the Ministry of Internal Affairs and Communication (Mitsutsugu, 2019). The Chinese government also showed interest in developing the electric vehicle, because of the rising pollution, which caused the Chinese government to change their policy (Ang et al., 2018).

Fire, Volcanoes, and so on release different types of pollutants to the environment. But the major cause of air pollution in the environment is because of anthropogenic activities. Many industries and vehicles release air pollutants causing a lot of harm to the environment and human health. Air pollutants in the human body can cause illness, increase the death, and be hazardous to the health of humans (Marilena et al., 2008).

BIODIESEL

Biodiesel is generally produced from vegetable oils or animal fats by the process of transesterification. Rudolf Diesel (1858-1913) was the one who originated the use of vegetable oil to be possibly used as engine fuel. He was the one who ran the primary engine with vegetable fuel (E. Sadeghinezhad et al., 2013). It is being preferred because of its continued availability, emission characteristics, limited resources, and increasing demand for petroleum, which increases the demand for biodiesel. It has a growing popularity as an alternative fuel because of its environmental and profitable benefits. An essential source of energy is the vegetable oils. But the oils can create many problems in the engine components. The different molecular structure, volatility, and the higher viscosity are the reasons for the engine component problems (P. McCarthy et al., 2011). Vegetable oils can be obtained from various sources. Glyceride is the vegetable oil that can be considered as an alternative for diesel fuel. They have very less sulfur and aromatic polycyclic compound in the exhaust emission and have good heating power. As these oils are produced from plants when they are burnt, they produce recyclable carbon dioxide (Mustafa et al., 2008). The higher cetane number of biodiesel is because of the long chain fatty acids with 2–3 double bonds. The oxygen content is around 10-11% oxygen by weight. Because of these characteristics, the emission of particulate matter, carbon monoxide, and hydrocarbon is reduced in the biodiesel. However, NO_x emission increases by 11% in the biodiesel (S. Rajesh et al., 2008). Microalgae biodiesel is the newly emerging field because of the derivation of high potential biodiesel. Even though the biodiesel has lower HHV (higher heating value) than petroleum fuels, it is higher than coal. Microalgae have the advantage of being environment-friendly. However, the production cost of this biodiesel is double the cost of petroleum oil (A. Avinash et al., 2015). In recent years, the use of nanomaterials has gained popularity. The nanomaterials used in the diesel enrich the diesel fuel property. It helps in the completion of the combustion process. It also helps in the reduction of pollution and gives better engine performance. In some research papers, diesel fuel was mixed with water in different volume concentration. Triton X-100 surfactant was used to in the diesel fuel to stabilize the water. 0.9 vol% water sample slowed the decrease in pollution (Ehsanollah et al., 2018).

ELECTRIC VEHICLE

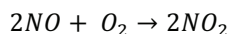
The electric vehicle was first constructed by Frenchman Gustave Trouvé in the year 1881. He built a tricycle which was powered by 0.1-hp DC motor and a lead acid battery. The weight of the vehicle, including the drive, was 160 kg. Morris and Salom's electrobat was the first electric vehicle commercially. The car was installed with a 1.5 hp motor. Almost after 18 years, the first hybrid electric vehicle was reported, in Paris Salon show in 1899. Pieper's

was a parallel hybrid electric vehicle with an electric motor and a gasoline engine which was air cooled. The gasoline engine was used to charge the battery of the vehicle while coasting and standstill. The motor used to work when power was required more than the engine power. In 1997, Toyota took the initiative to develop and commercialize hybrid electric vehicles and released Prius sedan. The civic hybrid was brought out by Honda (Mehrdad et al., 2009).

Electric vehicles and hybrid electric vehicles are solutions for reducing pollution from the vehicle exhaust. It has also been observed that the registration of electric vehicles and the hybrid electric vehicles is increasing day by day. Energy efficiency was improved and low pollution was reported from the hybrid electric vehicle from the previous work (Alberto et al., 2018). But the conventional vehicles are cheaper than electric vehicles and hybrid electric vehicles. The Indian government has invested in renewable energy sources like wind energy and solar energy and wants to increase their infrastructure. National Mission on electrical mobility was launched, which helps in creating a demand of about 5 to 7 million electric vehicles (two-wheeler, light vehicles, buses, and commercial vehicles by 2020 (Anu et al., 2015).

AIR POLLUTION

Gaseous pollutants contribute to air pollution and the burning of fossil fuels is the main reason. NO₂ is formed when ozone reacts to NO. The smell of NO is very bad. Generally, nitrogen dioxide that is formed in the atmosphere is either because of lightening or produced by water, soil, and plants. However, the formation of nitrogen oxide naturally or in this way only contributes to 1% of the total NO in our atmosphere. Vehicles using fossil fuels contribute to almost 80% of the nitrogen oxide in the atmosphere. Nitrogen dioxide is also produced by the power stations which are run by coal, metal refineries, and other manufacturing industries. Most of the NO is formed because of fossil fuels. Formation of NO₂ is shown in Equation 1. NO is very important to understand as it is the major contributor to the formation of photochemical smog. Nitrogen oxide is mainly formed by the burning of fossil fuels. In a research, it was found that the NO_x emission due to the vehicles at traffic congestion in the year 2006 was 39.59 x 10⁴ tons, which increased to 43.68 x 10⁴ tons by the year 2010, and by 2015 the emission of NO_x was 49.19 x 10⁴ tons. From 2006 to 2015, there is an increase of 24.24% in the emission of NO_x (Zhuang et al., 2019 & Rafael et al., 2020).



There is incomplete combustion CO is formed. It is formed because of the incomplete oxidation process. Amount of air fuel mixture defines the CO formation. Generally, during the start of the engine, the engine requires a rich mixture. During that time, the formation of CO is more because enough air is not available for conversion of carbon to CO₂. Even in the condition of less swirl, insufficient swirl or large diesel droplet size, the CO is formed (Ibrahim et al., 2015), whereas SO₂ is formed when fossil fuels are burnt, which contains sulfur. Therefore, air pollution has a different composition and varied time of exposure which leads to different effects in human health. Different human impact can range from difficulty in breathing, cancer, nausea, and skin irritation. It has also been observed that the air pollution affects the newborn infants and children the most (Marilena et al., 2008).

BIODIESEL AND ITS TYPES

Jatropha Oil

Jatropha curcas L. is a large shrub or small tree. The tree can be tall up to 5-7m which belongs to Euphorbiaceae family and has a life of 50 years. *Jatropha* oil is an excellent source of biodiesel. The plant leaves are 4-6 lob, 10-15cm in width and length and are smooth. The *Jatropha curcas* seeds are used for the production of *jatropha* oil. The

Jatropha plants can be grown in the wastelands. Jatropha plants seeds can give about 40% oil. The oil is extracted from the seed by manual ram press. The manual ram press can extract about 60-65% oil (W.M.J. Achten et al., 2008, and Jungmin et al., 2019). It was observed that the Jatropha oil improves the brake power and specific fuel consumption and brake thermal efficiency. 100 % biodiesel blend had lower HRR \square max. Jatropha has a higher viscosity, which leads to inferior atomization. The production of CO, HC, and NO $_x$ was less compared to conventional diesel fuels (Chetankumar et al., 2019).

Karanja Oil

Karanja is also known as Pongamia pinnat. It is a plant which grows abundantly along the riverbanks & coastlines. The plant requires very less land for the growth, but it requires ample sunshine overhead in the initial stage. In India, the plant could be found from Kanyakumari to the Himalayan foothills. The seedcases of karanja plant are shaped elliptical and contain only one seed. The size of the pods is 2-3cm in width and 3-6cm in length, with a thick wall. The seeds are inside the pods. The size of the seeds varies between 10 and 20 mm and they are brown in colour. The oil output of the seed is about 29-39%. As diketone pongamol and karanjin toxins are present in the karanja oil, it makes it non-edible oil. The annual yield of karanja is about 2-4 t/hector/year (Rupesh et al., 2017). Karanja is a non-edible oil and has a promising feedstock. It was seen that the karanja oil had similar properties to diesel and could be grown on wasteland easily. The karanja plant can yield about 96% biodiesel by transesterification. The karanja oil has been treated by transesterification for the use as biodiesel (Shubham et al., 2019). The cetane number of 100% karanja oil was found to be 50.8, whereas the mineral diesel oil was found to be 51.2 (Sanghoon et al., 2017). The biodiesel at higher load and engine speed showed lower CO emission. The hydrocarbon and NO $_x$ emission was higher when compared to conventional diesel at lower loads and engine speed. Increase in emission by 20.73% was observed by the use of karanja. Increasing the combustion temperature, boosting combustion phasing, the difference in oxygen content of the biodiesel, and the difference of the chemical composition of diesel and biodiesel are the reason for the NO $_x$ emission (Atul et al., 2014 and Pankaj et al., 2019).

Palm Oil

Elaeis guineensis, the fruit of the palm tree, gives two different types of oils. When the palm fruit is mesocarp, palm oil is obtained. The outer pulp of the fruit comprises kernels, which becomes a source of palm kernels oil. The two different oils are derived from the same fruit but have different properties and characteristics. C16:0 and C18:1 fatty acids are rich in palm oil (Oi-Ming et al., 2012). Figure 1 shows the palm mill conventional system. The production of palm oil requires a lot of natural resources such as water and forest land. But the production of the palm oil conduces to a lot of pollution to

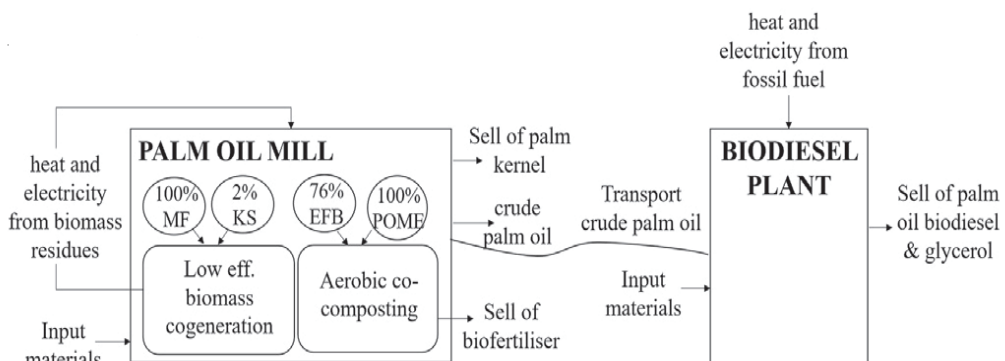


Figure 1. Palm oil mill conventional system (Kanokwan et al., 2017)

the environment such as eutrophication, air pollution, global warming, and acidification. Nutrients from the fertilized fields were leached. Acidifying compounds were from the mills, and fiber combustion in the boilers was the reason for smog precursors (Kanokwan et al., 2017). Indonesia is the largest producer of palm oil. The combined heat and power of the conventional palm oil mills are 2.0 MPa and 350°C steam. The boiler efficiency is down to about 70%. The biodiesel plant receives its raw material, that is, the crude palm oil from the palm mill. Co-product glycerol is also produced from the plant where biodiesel is the main product (Fumi et al., 2019). It is one of the maximum oil-producing plants, Palm oil. The palm tree is suited to grow in India because of its tropical climate (S. Senthilkumar et al., 2015). Palm oil with diesel in a combination of B30 showed lower NO_x at 10% EGR. But particulate matter was always less than 100 nm (Jun et al., 2020).

Coconut Oil

Coconut oil, Jatropha oil, and palm oil are the main components of the biodiesel source in Asia (H.G. How et al., 2014). Coconut oil is available in large quantity in Asia. It is low in cost, and it is a non-edible oil. Coconut oil has short chain length (C12 & C14). Unlike other natural oils, this reduces the viscosity in the biodiesel (Ting et al., 2016). The high amount of saturated fatty acids in coconut biodiesel made it have a lower flame temperature than diesel (Changhwan et al. 2016). Coconut has free fatty acid percentage of 12.8% (lauric acid), having 25.5 mg KOH/g acidic value in the oil. The oil has a brown colour. The oil is prepared by transesterification which is a chemically reversible process, also known as alcoholysis; this removes all the water molecules. The viscosity of the triglyceride is reduced by this process. Coconut oil has a high viscosity and low volatility same like the vegetable oils (Piyanch et al., 2010 & Azeem et al., 2019). Because of this, atomizing and mixing the oil with air is difficult. It cannot be used directly in the diesel engine. Coconut biodiesel has a high quantity of lower molecular weight methyl ester (M. Habibullah et al., 2014). The tropical eastern region is the origin of coconut. Coconut is mainly grown in central and south America, throughout the Asian continent and some parts of Africa. Coconut palm tree can produce 75 fruits in a year (João et al., 2010).

Moringa Oil

Oleifera tree belongs to the sub-Himalayan regions of northwest India family. It is grown in Arabian, Pacific, and Caribbean island, south Asia, Africa, and South America. Mainly, the oil is distributed in Cambodia, Tanzania, Philippines, and Central and North America. This plant has the capacity to tolerate soil pH, poor soil condition, and rainfall varying between 23 and 300 cm/year. 33-44% w/w vegetable oil could be produced from the moringa plant. The oleic acid content in the *Moringa oleifera* oil is more than 70%. It is being used in effleurage process and possesses resistance to oxidative degradation. This biodiesel has the highest cetane number. The cetane number is about 62.12, determined by Waukesha CFR F-5, with a varying density between 860kg/m³ and 900kg/m³ (G.Kafuku et al., 2010). The biodiesel can be prepared by the oil without any wastage. Transesterification of moringa oil to biodiesel takes place by the use of 1 wt. % KOCH₃ catalyst (Samuel et al., 2019). The MO seeds contain 39% (wt%) oil and fatty acids. The oil contains about 19% of saturated fatty acids and 81% of unsaturated fatty acids. It was also seen that 98 wt% in methyl esters was also found (Jhosianna et al., 2010).

Soybean Oil

Victoria was the first to produce Soybean commercially in the year 1980. Soybean is a crop which grows in irrigated summers. The crop suits climate that is high in temperature and with longer days. It is mainly used in the meal of stock feed industries and for oil extraction. Soybean is produced in large quantity in Brazil. Cultivation of 35 million hectares in the year 2017/18 (Rogério et al., 2019) took place. The yield of soybean oil is more than the yield of sunflower oil. The comparison shows that yield of soybean to sunflower is 2,668 kg/ha and 1500 kg/ha,

respectively. Soybean contains only 18% oil compared to sunflower oil which contains 26% oil. In the production of the soybean oil, nearly no nitrogen is used. To produce 1000kg of soybean oil, 5556kg of soybean is required. Net loss in energy is 8% (David et al., 2005). The oil has high brake specific fuel consumption, because of lower heating value, compared to diesel which is lower by about 10.2%. This biodiesel blend showed lower CO and HC emission because of the presence of oxygen atoms in the fuel (D. Subramaniam et al., 2013), but NO_x emission are higher (Medhat et al., 2019).

TYPES OF ELECTRIC VEHICLES

Battery Electric Vehicles

An internal combustion engine is replaced by electric motors which are powered by a battery in a vehicle, known as battery electric vehicle. The battery of the battery electric vehicle is charged by connecting it into a charging spot when the vehicle is idle. There are many advantages of the battery electric vehicle. Firstly they are less polluting and do not harm the environment. Secondly, they are highly efficient and could be charged in the night so that the car could be used in the day time. The only main disadvantage of battery electric vehicles is their high initial cost, which is the main barrier among the customers. Cost of battery would decrease with technological evolution, as shown in Figure 2. The customers have range anxiety. They think the trip would not be completed in one charge, and the time required to charge the vehicle is also long, unlike conventional vehicle in which one does not have to worry about the range. The range of anxiety is accelerated with a lower number of charging infrastructures. The range of the cars and the capacity of the battery are not linear. Many other factors reduce the efficiency of the battery. The battery of the BEV plays a vital role in the cost of the vehicle. According to the International Energy Agency, the battery price of the BEV should be less than USD 300/kWh, of the BEV are to be made popular.

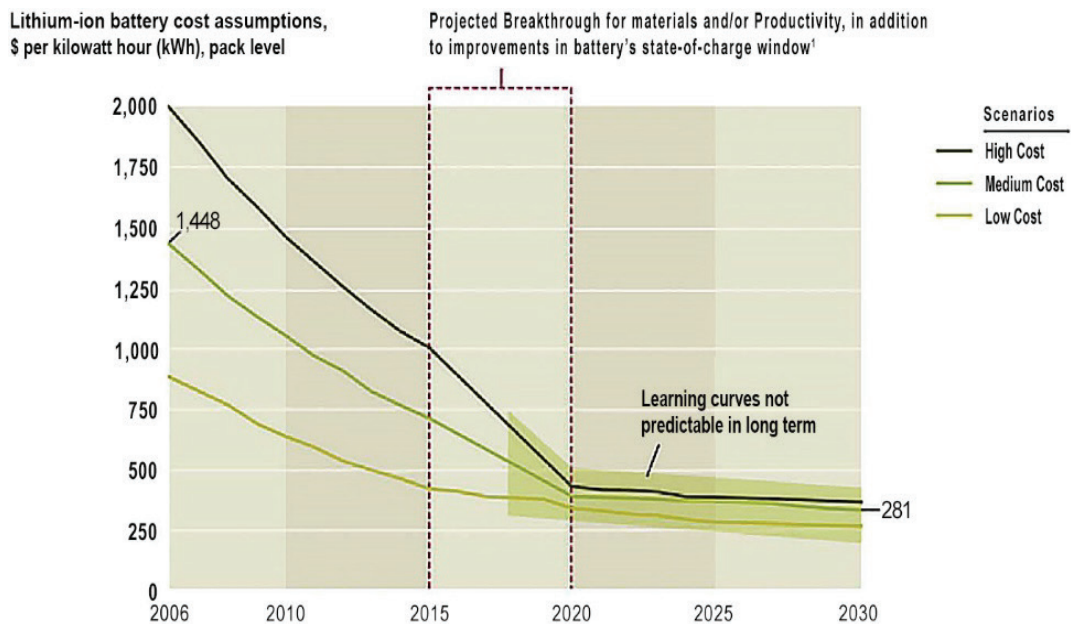


Figure 2. Cost evolution of li-ion battery (Amin et al., 2017)

Battery management system is an important component in the BEV. The main function of the BMS is to determine the state of charge, remaining useful life, and state of health of the battery. BMS also helps the battery to

run in a safe, undamaged, and efficient way. The motor used in the BEV is also important. Mainly, DC motor is suitable for EV. They are simple in use; the control system is simple and least costly. AC motors can also be used, as they are less expensive, but the electronics used are expensive and complicated (Amin et al., 2017).

HYBRID ELECTRIC VEHICLE

Series Hybrid Electric Vehicle

When a small internal combustion engine is added to an electric vehicle, it becomes a hybrid electric vehicle. The internal combustion engine helps in balancing the energy shortage from the battery electric vehicle. Because of the simple structure of the series hybrid electric vehicle as shown in Figure 3, it is primarily used in heavy commercial vehicles. There are many advantages of a series hybrid electric vehicle.

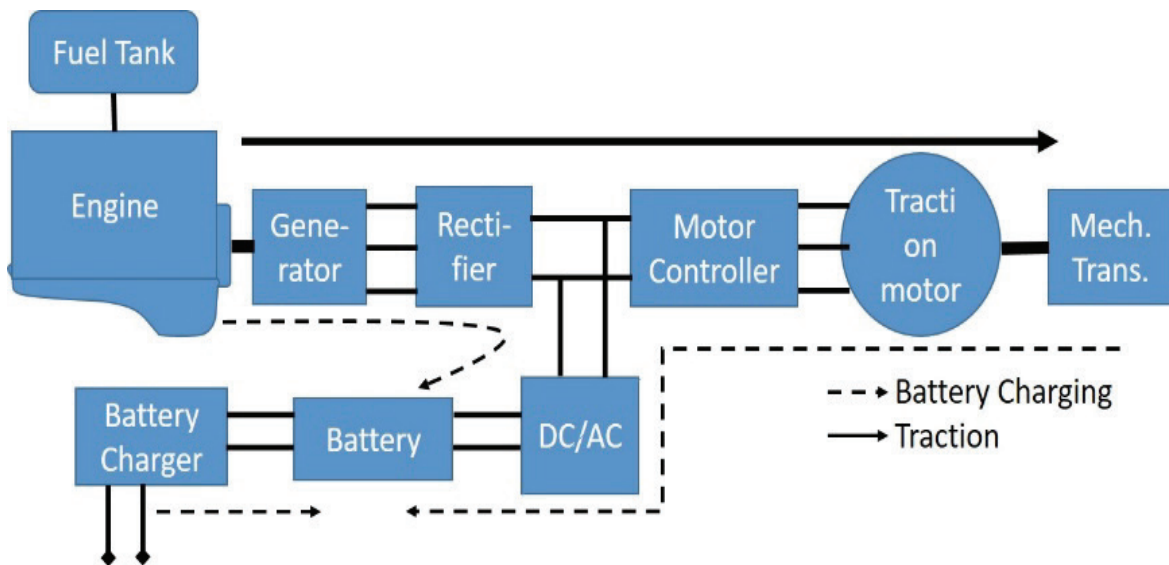


Figure 3. Drivetrain of series HEV (Mehrdad et al., 2009) **Error! Reference source not found.**

The torque is from a single motor (source), which becomes simpler to control the speed. Mechanical decoupling is between the driven wheel and the internal combustion engine. HEV has simple structure, easy packaging, and drivetrain control, whereas conversion of energy is two times, inducing energy loss. Torque source for the wheels is only the traction motor (Mehrdad et al., 2009).

Parallel Hybrid Electric Vehicle

Through a mechanical coupling, the electric motor and the internal combustion engine both can power the wheel individually. Mechanical coupling could be a single axle, pulley belt, gear box, or sprocket chain. As mechanical coupling (mechanical coupling hybrid drivetrain) is being used, engine operating condition cannot be fixed. But as there is less conversion of power, therefore the power loss is less, unlike the series hybrid electric vehicle. Both the engine and the motor can supply power to the wheel. Therefore, the losses are less as depicted in Figure 4. And as there is no generator, like the series-HEV, the structure is simpler and compact. Because of these advantages, the parallel-HEV is preferred in the passenger vehicles (Mehrdad et al., 2009 & Yimin et al., 2006).

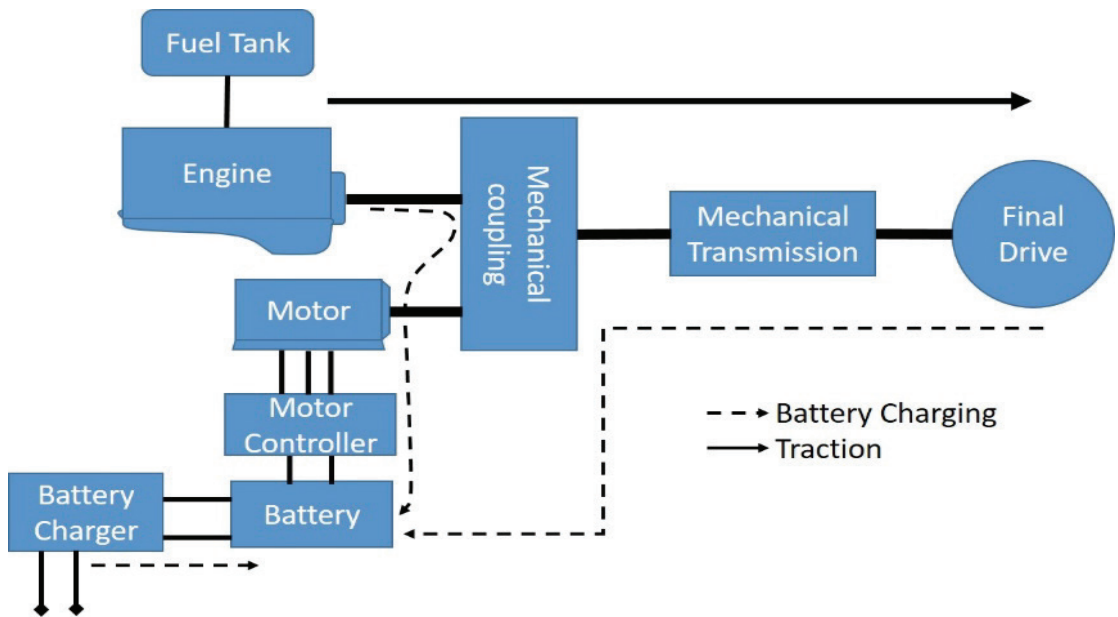


Figure 4. Parallel hybrid electric vehicle diagram (Mehrdad et al., 2009)

Series–Parallel Hybrid Electric Vehicle

Disadvantages of both series-HEV and parallel-HEV are overcome in the series-parallel hybrid electric vehicle (Yimin et al., 2006). The planetary gear system is used in series-parallel hybrid electric vehicle as shown in Figure 5. It is used to decouple the engine speed from the wheel.

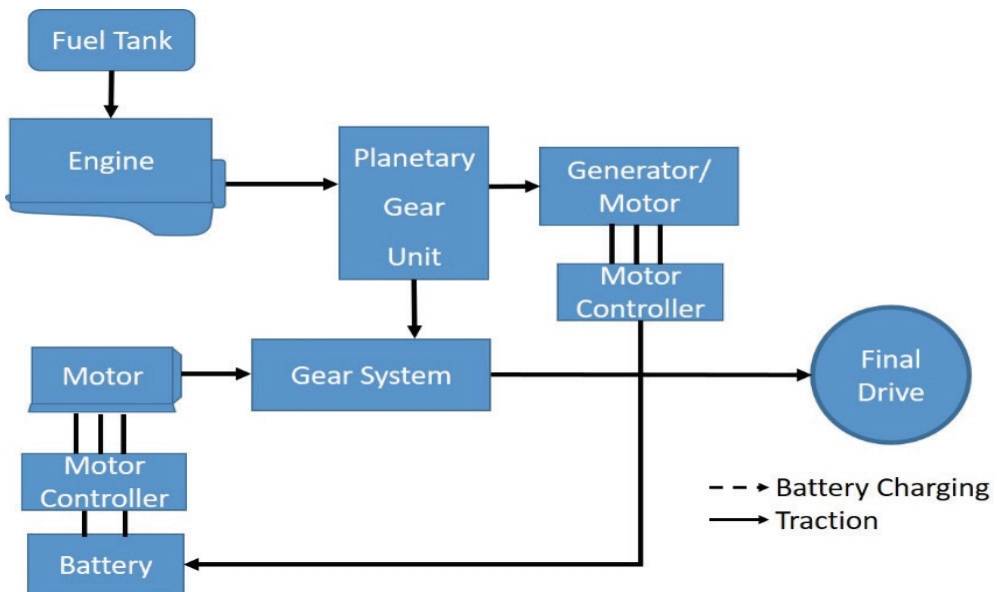


Figure 5. Series parallel hybrid electric vehicle configuration (Mehrdad et al., 2009)

The engine, motor, and the planetary gear form the series flow of power as shown in Figure 6. Motor works in the opposite direction of the torque; it is generating power. Engine speed is divided to reach the generator and the other to the drivetrain as depicted in Figure 7. When the generator is positive, it works to provide power to the wheels. The series-parallel architecture that became famous was the Toyota Hybrid System, allowing all power demand and giving a good performance. For off-road vehicles, series-hybrid architecture is fresh. The engine is at its highest operating region giving best efficiency by the control strategy, depending on the battery state of charge and power request. HEV mainly operates on charge sustain mode (Mehrdad et al., 2009& Yiming et al., 2012).

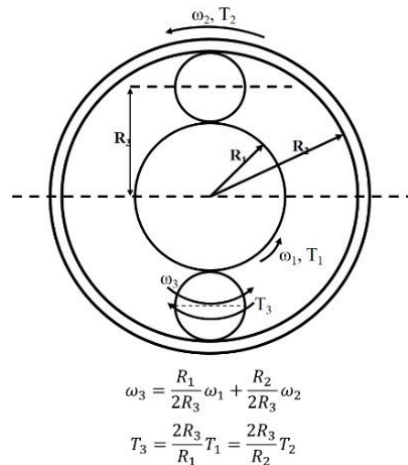


Figure 6. Planetary gear system (Mehrdad et al., 2009)

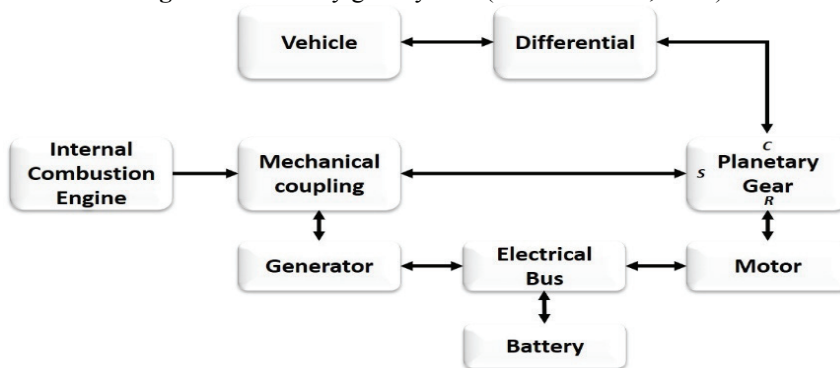


Figure 7. Series-parallel hybrid electric power train block diagram.

Plug-in Hybrid Electric Vehicle

Plug-in hybrid electric vehicles have similar architecture and components like the conventional hybrid-electric vehicle depicted in Figure 8. In both vehicles, IC engine and electric motor drivetrain are connected to each other, and are connected to the road. PHEV has an additional charging port that is extra compared to the HEV, which helps PHEV to charge and stock energy when connected to a charging point. PHEV has fuel energy and battery energy which can be used individually or together. This system helps the PHEV to be driven with lower emissions, better efficiency, lower cost, and higher performance than the HEV. Plug-in electric vehicle different power management modes are as follows electric vehicle mode, internal engine mode, charge depleting mode, and charge sustaining mode. Switching between the modes can be automatic or dependent on the driving condition. PHEV has batteries or

regenerators which are used to store energy. PHEV has a power management task, which monitors the battery state of charge. But replacing the battery is very costly and is a potential component of vehicle lifecycle cost. It is estimated that the battery has a life of 10 years or 161,000 to 210,000 km (Yiming et al., 2012 & Thomas et al., 2009).

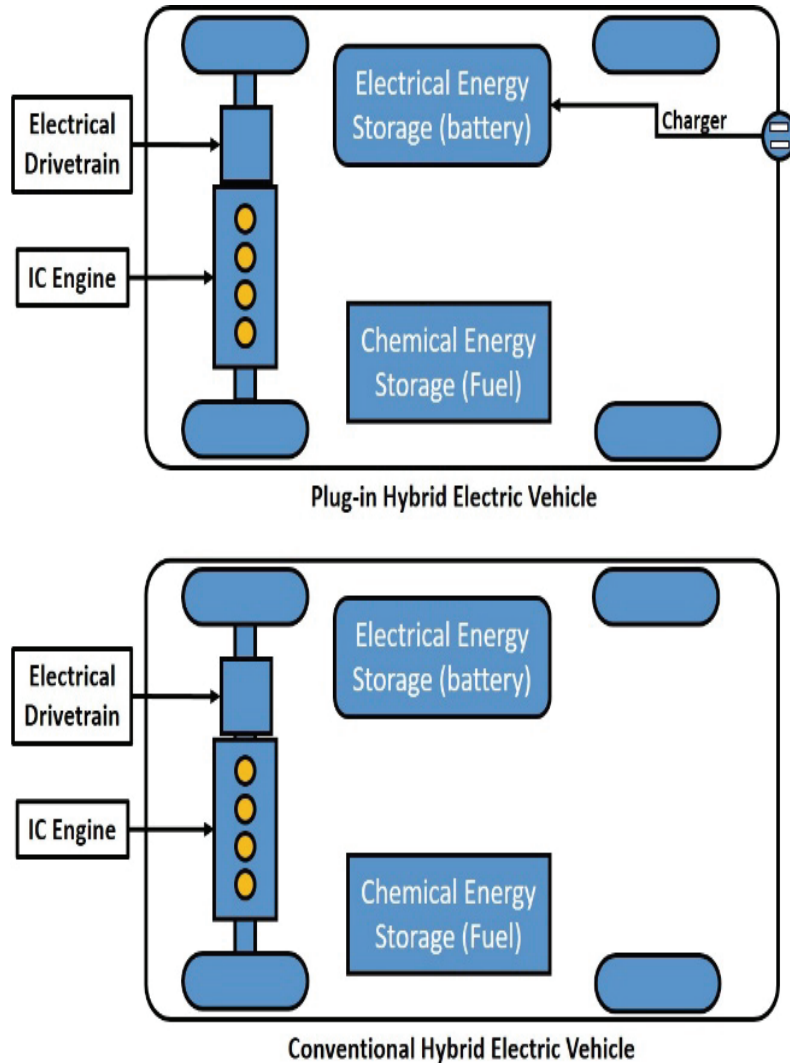


Figure 8. PHEV outline (Thomas et al., 2009) **Error! Reference source not found.**

Exhaust Emission Analysis

The exhaust gas temperature of the coconut biodiesel blend showed at 100% throttle. The 15% coconut biodiesel blend showed the maximum exhaust temperature which was about 3.33% more than 100% diesel exhaust temperature. But, in the case of 8-% throttle condition, the maximum exhaust temperature was observed for CB15 having 5.96% higher temperature than 100% diesel fuel. It was also observed that the coconut biodiesel blend had low CO emissions for both 100% and 80% throttle as shown in Figure 8. CO₂ emission at 100% and 80% throttle at 2200rpm showed that CO₂ was more by 4.56% for 15% coconut biodiesel blend and even in the case for NO_x emission (A.M Liaquat et al., 2013).

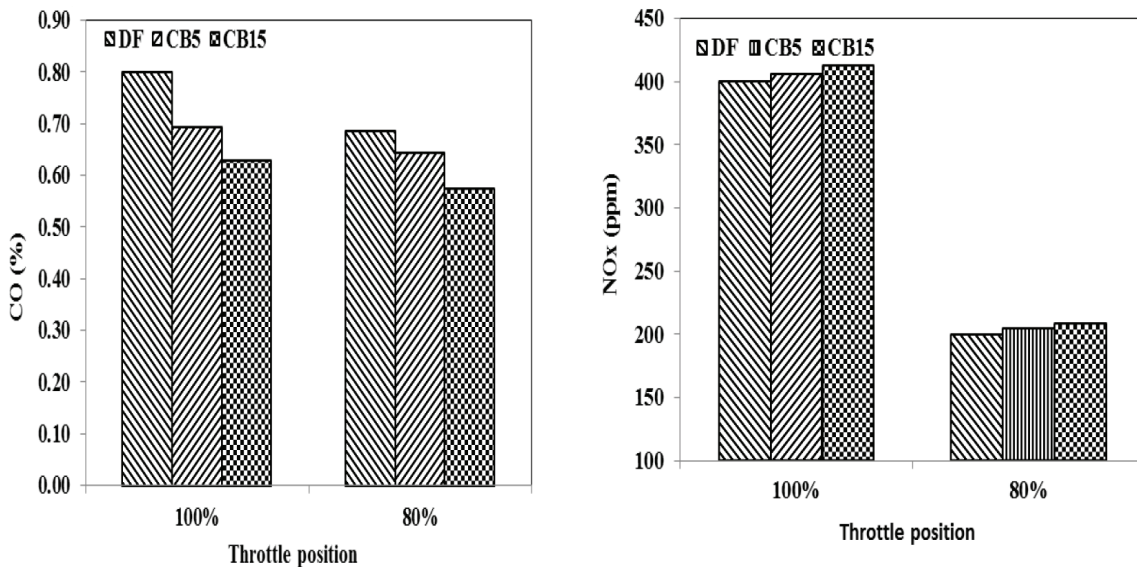


Figure 8. CO₂ and NO_x relation with throttle (A.M Liaquat et al., 2013)

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Hydroxyl compounds solution-in-diesel emulsion, glucose solution-in-diesel emulsion, synthetic bio-oil-in-diesel emulsion, and aldehydes solution-in-diesel emulsion were used to experiment the engine performance and the emission. It was observed that the exhaust gas temperature of the emulsion fuel and the diesel fuel did not have much difference with the engine load. The low exhaust temperature was because of the higher emulsion viscosity and because of which there were low-quality injection and incomplete combustion. CO emission increased with the engine load, and at high load the fuel-rich mixture increases. CO is formed because of the incomplete combustion, but in the case of biofuels the CO formed is fewer because the fuel is rich in oxygen. The NO_x emission was increased for all test fuels with the increase in the load (Xingzhong et al., 2018 & K.A. Abed et al., 2019). 50% Jatropha methyl ester and 50% turpentine oil emitted low NO_x emission during the ideal condition, because of the shorter combustion duration and the ignition delay is high. Lower NO_x was reported with pine oil and kapok methyl ester oil. It was also observed that NO_x emission was decreasing with the increasing break power (Pankaj et al., 2017 & A.K. Jeevanantham et al., 2020). The level of CO emission in dual fuel operation in which one fuel is natural gas and the other is biofuel is high. The CO is converted to CO₂ because of incomplete combustion, low gas temperature, and shortage of air (N. Panneerselvam et al., 2015). By changing the nozzle axis location, CO was found to be low and NO_x emission increased at high engine speed. This was caused by the higher cylinder peak temperature (Amin et al., 2015). The use of biofuel blend with methanol showed an increase in CO₂, CO, and NO_x emission, and the use of biofuel blends with alcohol as a substitute for conventional diesel fuel was suggested (S. Thiyagarajan et al., 2020). In another situation, the mixture of 20% biodiesel in 80% diesel helped in the reduction of CO₂ by 12.6% and hydrocarbon by 11% in the city of Bangkok (Manjula et al., 2009). NO_x emission from the cottonseed oil is higher than n-butanol or diethyl ether because the latter oils have high cetane number and higher heating value. N-butanol and diethyl ether have lower CO emission than cottonseed biodiesel blend and pure cottonseed oil (D.C. Rakopoulos, 2013 & Dimitrios et al., 2015). In another case, it was seen that the NO_x emission increased with the increase in heat release and combustion. NO_x was the maximum at 100% load with 100% biodiesel. Emission was almost 17% higher than diesel as could be seen in Figure 9. NO_x emission was low with the addition of n-butanol to the biodiesel blend, and lower temperature was caused by the high latent heat of evaporation (S. Senthur et al., 2017). Sunflower oil blend and cottonseed oil blend showed that NO_x emission is higher than diesel fuel, and cottonseed biodiesel blend exhibited higher NO_x emission.

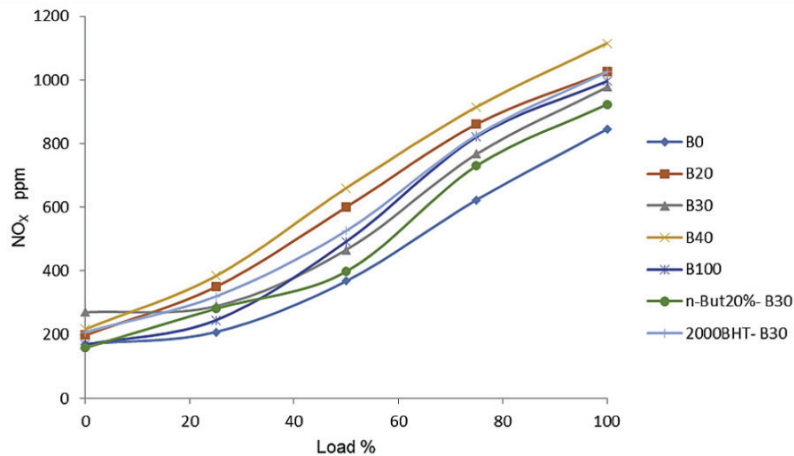


Figure 9. NO_x variation with different biodiesel blends and loads (S. Senthur et al., 2017)

The HC produced from the cottonseed biodiesel was higher than all other oils, but overall the biodiesel blends (cotton and sunflower) had higher HC emission than diesel (C.D. Rakopoulos et al., 2008). Biohydrogenated diesel was produced from fatty acid methyl ester and palm oil fatty acid distillate. They had a negative GHG emission because CO₂ was absorbed by the palm oil plants during cultivation of the plants. The palm trees are a CO₂ sink. Greenhouse gas emission from biohydrogenated diesel by fatty acid methyl ester production was low than palm oil fatty acid distillate. Biohydrogenated diesel by fatty acid methyl ester production required 1.77kg of crude palm oil, whereas biohydrogenated diesel by palm oil fatty acid distillate required 44.44kg of crude palm oil. In both cases, there is 1kg of biohydrogenated diesel (Bulin et al., 2017). When using cottonseed biodiesel by 50% and ethanol by 50%, it was seen that the CO emission increased at lower loads with increasing ethanol content, but in the case of NO_x it was observed that, with an increase in ethanol, the NO_x emission decreases. Ethanol increased atomization by increasing viscosity (B. Prbakaran et al., 2018). In another case, soybean biodiesel was studied, and it was seen that 100% biodiesel had higher NO_x emission and 19.2% more NO_x emission (Suresh et al., 2018 & Suresh, 2020). Linseed methyl ester biodiesel was compared with base diesel and it was observed that the biodiesel had low CO emission than base diesel. The diesel had 1.64% more CO emission. The hydrocarbon emission was lower than diesel for the linseed methyl ester biodiesel (Narath et al., 2019). With the increase in biodiesel, the NO_x emission also increases. Cottonseed or sunflower biodiesel blend oils showed an increase in NO_x emission with an increase in the biodiesel blend (D.C. Rakopoulos, 2012).

Many different types of hybrid vehicle were studied. Greenhouse gas emission was reduced by 8% during the off-peak charging pattern. When Dutch grid was used for charging the electric vehicles, greenhouse gas emission was 33-77 g Km-1. Emission, when compared to conventional cars, was 51-78% lower. 30% penetration of electric vehicles would increase 3% of the electricity demand. If the electricity is generated by natural, gas then there would be 0 g km-1. But, in the case of coal-based power plant, the GHG emission would be 155 g km-1 (Oscar et al., 2011). In another case, an experiment was conducted to test the fuel economy and emission of hybrid vehicles. The hybrid vehicle was found to produce less CO₂ in city drive than highway (Georgios et al., 2008 & Hüseyin Turan Arat, 2019). Goods vehicle driven by electric drive were estimated to reduce the CO₂ emission. Predictions were made about the market share of the hybrid electric vehicles, 82% stock of hybrid electric vehicle and 65% of battery and fuel cell vehicles. Even if maximum hybridization was carried out, by 2050 diesel and gasoline vehicle will account for 52% of the energy consumption. CO₂ emission would be reduced by 55.8% tank to wheel, by the battery electric vehicle and hybrid electric vehicle (Juan et al., 2012). The CO, NO_x, and PM2.5 were reduced by 1500, 33.9, and 7.2

Gg yr-1 by the incursion of the electric vehicles by 20.6 million vehicle fleet in Taiwan. Electric vehicles were mainly charged by the thermal power plants which increased the NO_x by 20.3Gg yr-1. Electric vehicles would improve the surface concentration of NO_x and CO by 3.3 ppb, 260, respectively, annually, but the SO₂ would be increased. CO₂ emission was low as shown in Figure 10, and CO₂ emission from electricity grid is lower than diesel emission as shown in Figure 11(Nan et al., 2016). In Brazil, the impact of an electric vehicle.

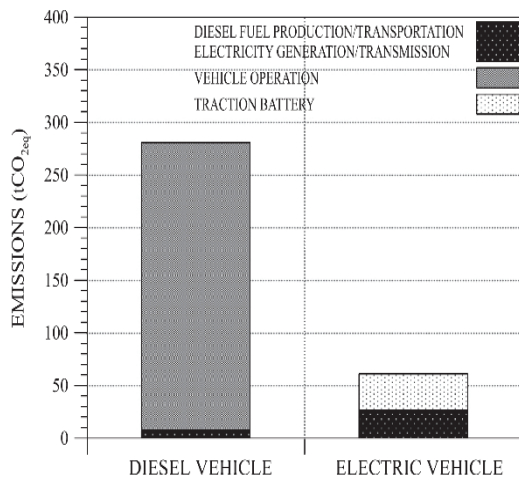


Figure 10. Diesel vehicle and electric vehicle carbon dioxide emission (Nan et al., 2016)

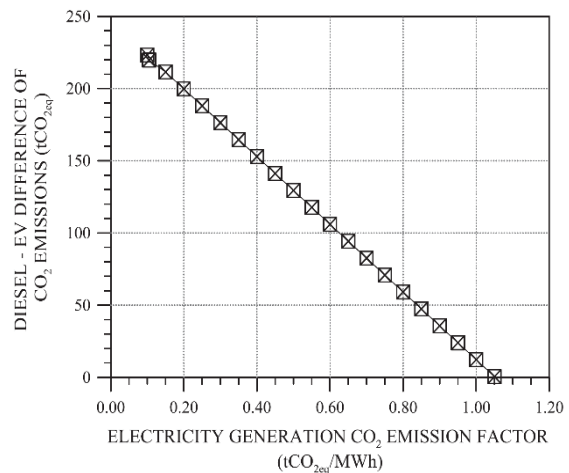


Figure 11. EV and diesel CO₂ emission when shaped by emission factor (Nan et al., 2016)

Even if the transport fleet is made electric the electricity consumption of 40 million MWh. 2% increase in electricity with 10% electric car addition every year (Marcos et al., 2014). In the case of the electricity mix, 0.25 kg CO₂/kWhel and 50 g CO₂/km were analyses for time-dependent average electricity mix and controlled charging strategy of the electric vehicle respectively. But in the case of marginal electricity mix the emission was 0.55 kg CO₂/kWhel & 110 g CO₂/km for the uncontrolled charging of the electric vehicles. In the case were the countries are dependent on the thermal power plant for the generation of electricity CO₂ emission would not meliorate significantly (Partick et al., 2015). Even when electric vehicles and conventional vehicles were compared the CO₂ emission 4.6 times higher in the conventional vehicles. It was also expected that the electric vehicles will pollute more than diesel vehicles if the electric matrix exceeds 1.05 kg CO₂/hWh. The value is 13 times more than 2016 value in Brazil (Eduardo et al., 2017).

In Brazil, the engine powered vehicle was replaced by electric vehicle and the analysis revealed that if 75% taxi fleet were gradually substituted with the electric engine by 2030, 3100 tons of CO₂ would be reduced if the taxi is running for 200km a day. In another case, if the taxi fleet is running for more than 400km a day the reduction in CO₂ would be around 3800 tons of CO₂ to 4200 tons of CO₂(Ana et al., 2018). In Japan, the road freight vehicles were analyzed and were noted that the tank to wheel CO₂ emission would be boiled down from 98 to 47 Mt- CO₂/year for the period 2012-2050.

With the use of Hybrid electric vehicles, fuel cell electric vehicles, zero-emission vehicles & battery electric vehicles the Well to wheel CO₂ emission could be reduced to 5.3, 27.6, 29.5, 43.9% respectively when compared to the base value. It was also stated that BEV and FCEV diffusion could reduce tank to wheel CO₂ up to 55.8% by 2050 (Juan et al., 2012). Where many European countries are diffusing electric vehicle into the fleet to decarbonize. But many European countries like Netherland, UK and Germany have power generation plants which produce more pollution (Luc et al., 2016). Estimations were made that Europe would have 2 million charging points by 2017. 3%

would be rapid charging points of the 2 million (Jaroslawet al., 2017). Battery electric vehicle use in Sweden created 7-9 g CO₂eq/km, 169-234 g CO₂eq/km was emitted by electric vehicles in Latvia whereas the average emission in Europe was 65-89 g CO₂eq/km. Plug-in hybrid electric vehicle at 88% state of charge showed more of NO_x, NH₃, CO₂ and CO emission than full state of charge. PHEV show different functioning at different SOC (R. Suarez et al., 2016). Real driving and laboratory results were different for hybrid electric vehicle and conventional vehicle. Hybrid electric vehicle had 44-100% more consumption than lab and 30-82% for a conventional vehicle. Hybridization of vehicle powertrain would not bring any welfare to air quality (Yuhan et al., 2019). In the Italian cities, it was observed that vehicle which complies with the Euro 4 norms had emission 10 times higher in the real condition. Electric vehicle had 12% lower CO₂ emission when compared to the conventional vehicle in the case of life cycle assessment of CO₂. CO₂ emission from the electricity generation plant by the different fuels were Gas (1.489 kg/kW h), municipal solid waste (0.897 kg/kW h), biogas (0.432 kg/kW h) are depicted in figure 12(T.Donateo et al., 2015).

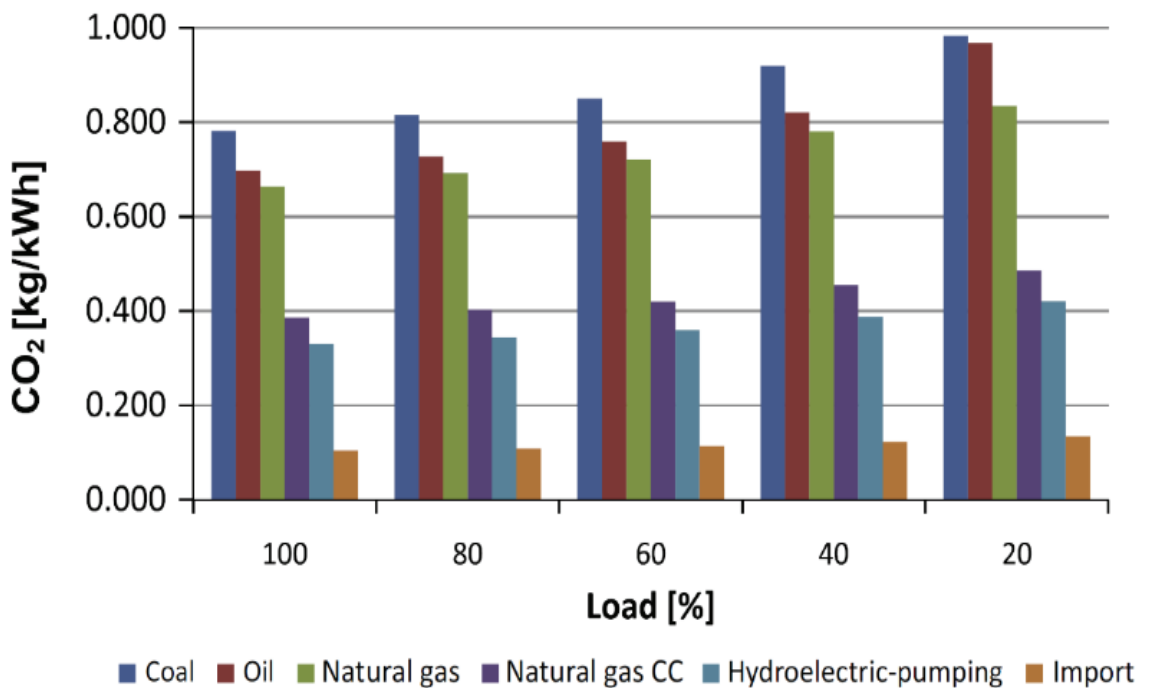


Figure12. CO₂ emission in the Italian power generation plants (T.Donateo et al., 2015)

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Electricity used by the electric vehicle in Scandinavia and Germany produced about 3-17 MtCO₂ based on Electricity System Dispatch model for the year 2030. Emission for burning fossil fuels would be around 29-136 Mt CO₂. 15g CO₂/km would be for the passenger electric vehicle when given supply from the electric generation plant. By the year 2050, very low CO₂ emission would be allowed do investment in the wind power and thermal power (using CCS lignite co-fired with biomass) would be used to generate power for the EV (M. Taljegard et al., 2019). Mild hybrid vehicle reduced the GHG emission very slightly, but the heavy hybrid vehicle is expected to reduce the GHG emission more. An electric vehicle with 100km range has the lowest GHG emission but the electric vehicle with 200 & 300 km range have higher GHG emission than the heavy hybrid vehicle as shown in figure 14(Amin et al., 2017).

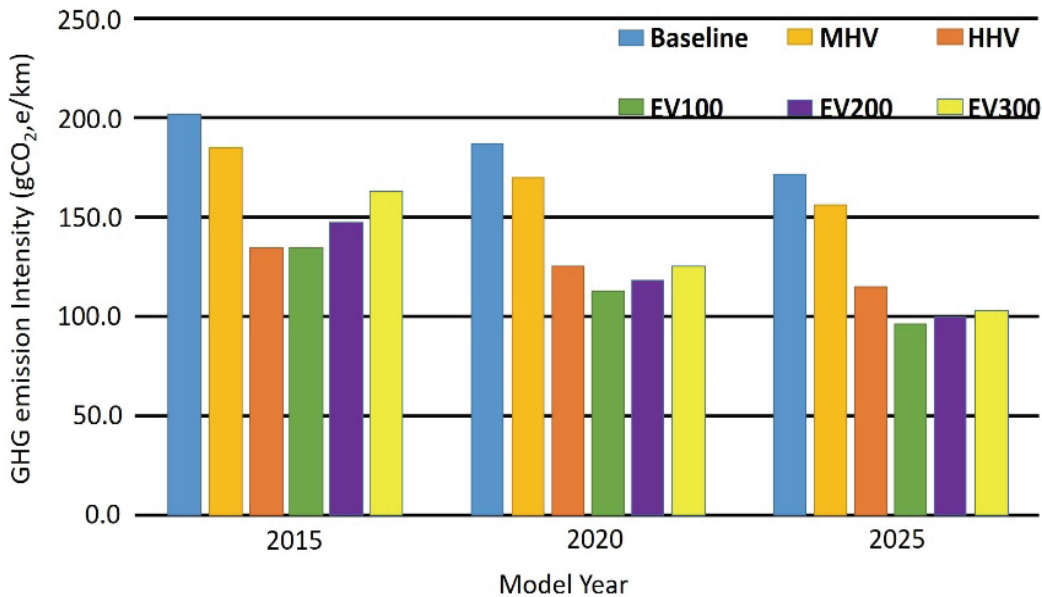


Figure 14. GHG emission (Amin et al., 2017)Error! Reference source not found.

HEALTH EFFECT OF VEHICULAR EMISSION

Air pollution affects human health in different ways and different degrees. Many pollutants affect the respiratory and cardiovascular system directly. There is an increase in mortality, impaired pulmonary function and morbidity because of the high level of SO_2 and suspended particulate matter. (Aayush et al., 2018). It was observed that the vascular constriction was boosted through pollutants. Even when the body is exposed to air pollution it leads to brachial artery vasoconstriction. This type of problem was seen in adults with smoking and non-smoking habits. But exposure to Air pollution resulted in a change in heart rate variation and blood pressure (Ubiratan et al., 2005). In a study in Delhi, India showed that the respiratory-related problems increased when the air pollution increased and the numbers of emergency admission also increased in number. In Delhi, the eye irritation, headache and skin irritation increased because of the increase in air pollution (SA Rizwan et al., 2013). PM and NO_2 increase would lead to inflammation in the airway (Frederick et al., 2008). Respiratory problems escalated in the children's with exposure to low- NO_x (Guy et al., 2010). NO_x emission in another paper resulted in health damage (Denise et al., 2005). A study in china on electric vehicles showed that the increase in electric vehicles will increase the CO_2 emission and will, in turn, increase the mortality risk (Shuguang et al., 2012). Direct relation with respiratory problem and NO_2 was found and relation with asthma was found to increase with the exposure to NO_2 exposure. In the case of CO , it leads to headache and deaths (Tze-Ming et al., 2007).

CONCLUSION

As fossil fuel is being used till now for running the vehicles. It was estimated that 90% of the transportation sector is dependent on fossil fuel. Fossil fuel is limited and the burning of the fossil fuel generates a lot of emissions, it has become necessary to shift to other alternatives to power the transportation sector. Alternate fuel such as biodiesel are being used in different parts of the world. Even electric vehicle and hybrid electric vehicle are gaining popularity. Electric vehicles are no polluting vehicles but to charge the electric vehicles, we need electricity, which

is being generated by the power plants and power plants which use fossil fuels to generate energy. So burning biodiesel or driving a EV or HEV would also result in polluting the environment and damaging the human health. Following conclusions were drawn from the review:

- CO₂ emission by coconut biodiesel blend were 4.5% more than conventional diesel and even in the case for NO_x emission. NO_x emission from the cottonseed oil was higher than n-butanol or diethyl ether because the later oils have high cetane number & higher heating value. NO_x emission also increases with increase in blend ratio.
- Bio-hydrogenated diesel was produced from fatty acid methyl ester and palm oil fatty acid distillate. They had a negative GHG emission because CO₂ was absorbed by the palm oil plants during cultivation of the plants.
- In the case of electric vehicles, the emission when compared to conventional cars was 51-78% lower. But with every 30% penetration of electric vehicles, electricity demand would increase by 3%. GHG emission by thermal power plant would be 155 g km⁻¹, NO_x would increase by 20.3 Gg yr⁻¹ and under maximum hybridization CO₂ would reduce by 55.8%
- Pollutants affect the respiratory and cardiovascular system directly. There is an increase in mortality, impaired pulmonary function and morbidity because of the high level of SO₂ and suspended particulate matter.

It can be inferred that with introducing electric vehicles into the fleet will decrease the emission, drastically. Biodiesel is an alternate to conventional fuel but has high NO_x emission which is harmful to human health. The emission from the thermal powerplants will somehow result in damage to the health of humans and will affect the environment. In the case of using electric vehicles, electricity should be generated from a renewable source of energy so that the emission could be controlled and the health impact is less. More importance should be given on the development of alternate fuels, which could help in generating electrical power and be used in vehicles and is safe for human health.

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