



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 10, October 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

Comparative Study on Environmental Effects of Internal Combustion Engine and Battery Electric Vehicles

Vaisak V

Lecturer, Department of Automobile Engineering, SCMS College of Polytechnics, Kerala, India

ABSTRACT: Electric vehicles continue to gain popularity as society encourages us to reduce pollution in our environment. Continuous efforts are made to reduce the lifecycle contribution of the automotive sector in carbon dioxide (CO₂) emissions, the main greenhouse gas, focusing mainly on the manufacturing and use phases. Battery Electric Vehicles (BEVs) are widely accepted as the next technology paradigm due to their significantly decreased emissions compared to conventional gasoline or diesel Internal Combustion Engine Vehicles (ICEVs) during their use. In the specific study, since electric vehicles produce no tailpipe emissions the production and decomposition of their components must be analysed a Well-to-Wheel framework has been studied to compare the contribution of ICEVs and BEVs into air pollution, including the entire process of the energy flow from the extraction of the energy source up to the vehicle being driven.

This study shows that in most cases BEVs have lower life cycle greenhouse gas (GHG) emissions than ICEVs. In general, GHG emissions associated with the raw materials acquisition and processing and the vehicle production stages of BEVs are higher than for ICEVs, but this is typically more than offset by lower vehicle in-use stage emissions, depending on the electricity generation source used to charge the vehicle batteries. With continued research, we will see more eco-friendly electric vehicles in the future.

KEYWORDS: Internal Combustion Engine vehicle; Battery Electric vehicle; Well-to-Wheel; Fuel consumption; Electricity consumption; CO₂ emission; Life Cycle Assessment; New; Electricity generation mix; Gasoline vehicle; Diesel vehicle.

I. INTRODUCTION

Battery electric vehicles (BEVs) do not consume gasoline or produce tailpipe carbon emissions, placing the promise of an environmentally sustainable driving experience within reach of the average consumer. However, the question remains: “Do BEVs truly offer an environmental advantage with respect to global warming potential and secondary environmental impacts – and if so, at what cost?” Based on our study, the ultimate environmental and economic reality of electric vehicles is far more complicated than their promise. From an economic perspective, BEVs enjoy some distinct advantages. First, the electricity cost associated with operating a BEV over a distance of one mile is significantly lower than the gasoline cost required operating a comparable ICEV over the same distance. Second, BEVs cost less to maintain, owing to the relative elegance and simplicity of a battery-electric motor system compared with the frequent maintenance required for operation of an internal combustion system. Broadly speaking, a review of the literature shows that in most cases BEVs have lower life cycle greenhouse gas (GHG) emissions than ICEVs. In general, GHG emissions associated with the raw materials acquisition and processing and the vehicle production stages of BEVs are higher than for ICEVs, but this is typically more than offset by lower vehicle in-use stage emissions, depending on the electricity generation source used to charge the vehicle batteries.

The importance of the electricity generation source used to charge the vehicle batteries is not to be understated: one study found that the carbon intensity of the electricity generation mix could explain 70% of the variability in life cycle results. The transition toward electric vehicles (EVs), and in particular toward electric cars for private mobility, is seen as a great opportunity both for decarbonizing the transport sector and for improving air quality in highly populated urban areas. Results from these comparative LCAs show that for most environmental impact categories (e.g., climate change, air acidification), electric cars are preferable to traditional cars. To compare the contribution of different vehicular technologies into air pollution, an analysis on the Well-to-Wheel process is proposed; this refers to the entire energy flow, from extracting fossil fuel or generating electricity up to a vehicle being driven.

II. INTERNAL COMBUSTION POLLUTION

A. Vehicle running pollution

Road-vehicle emissions continue to dominate urban air pollution. The most important pollutant emissions from light-duty, gasoline-powered vehicles are volatile organic compounds (VOCs), carbon monoxide (CO), and oxides of nitrogen (NO_x), whereas for heavy-duty, diesel vehicles, NO_x and fine particulate matter (PM_{2.5}) are of the greatest concern. VOCs and NO_x react in the presence of sunlight to form ozone and photochemical aerosols. Control technology applied to light-duty vehicles using precise, computer-based fuel-air mixture control and three-way catalyst aftertreatment combined with improved fuel quality have reduced the emissions of VOCs, CO, NO_x, and PM from new vehicles by more than 99%, as compared with 1970.

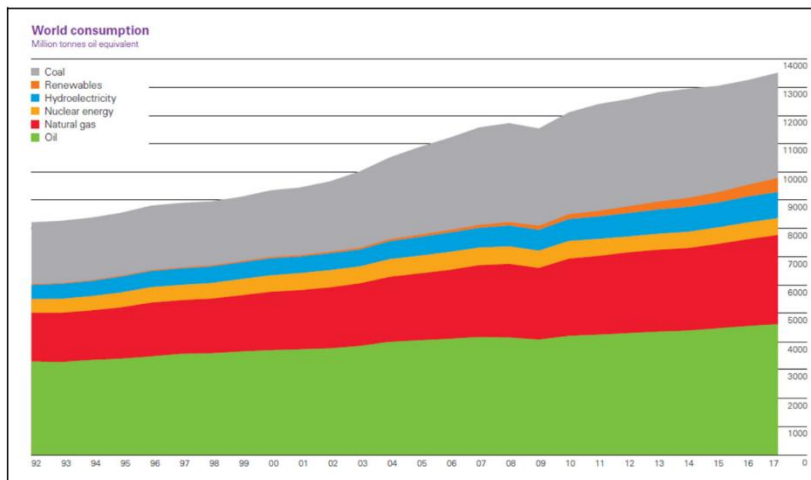


Fig. 1. World energy consumption by source (millions of petroleum equivalent) in the last 25 years.1 About 70% of fossil oil (i.e. about 3000 Mtoe) is consumed in IC engines.

The transport of goods and people are essential to modern society, and currently transport is almost entirely powered by ICEs using liquid fuels due to their plentiful supply, convenience and affordability. It is important to note that there are still no real alternatives that can compete with the IC engine over the entire range of applications that they cover and that, even today. Over the last four decades, in response to air-quality concerns, research on engine combustion, exhaust after-treatment and controls has led to a demonstrably cleaner environment thanks to a 1000-fold reduction in hazardous exhaust emissions (particulates, NO_x, CO and unburned hydrocarbons (uHCs)).

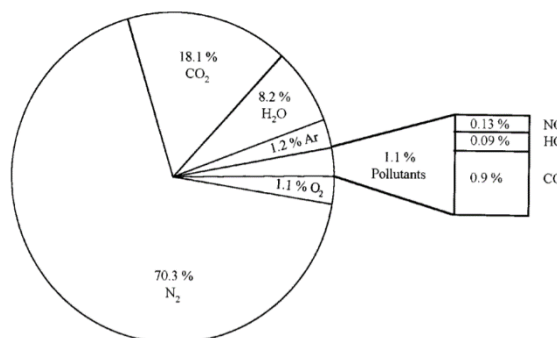


Fig. 2. Mean exhaust composition without catalytic converter in ECE test (medium-size vehicle)

Emissions of pollutants vary between different engines and are dependent on such variables as ignition timing, load, speed, and in particular, fuel/air ratio. The technology has had countless hours of research to lower production costs and efficiency. It is important to note that among internal combustion engines, diesel fuel combustion engines produce less emissions than gasoline, 5 and both are accounted for in all the studies used in this comparison.

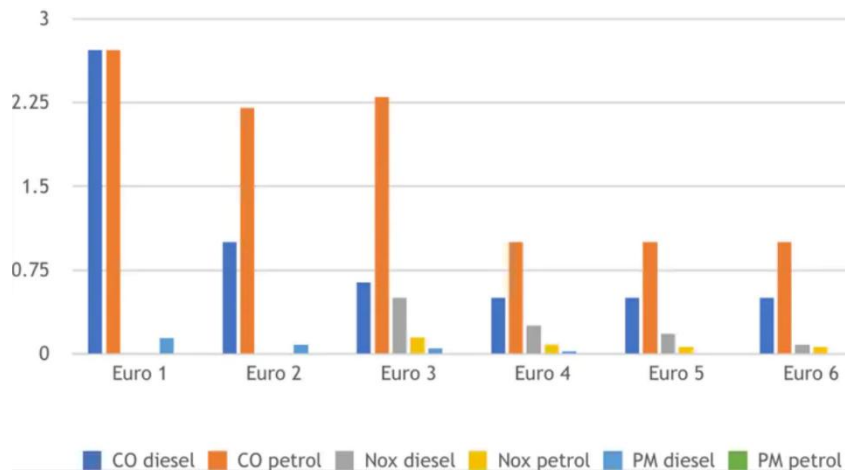


Fig. 3. EU toxic emission limits

in order to achieve these standards, diesel engine manufacturers have had to resort to technologies such as particulate filters, which tend to clog up when used mainly for urban driving. And the latest emissions technology requires the owner to regularly add a urea mixture such as AdBlue to the engine. By contrast, petrol emissions systems regulate themselves, needing less driver input. For most cars built over the past 20 years that may still be in use, petrol is likely to be less polluting overall than diesel. Petrol cars also require less maintenance to keep them performing at that level. But new, well maintained diesel cars, built to the latest standards have similar emissions to new petrol vehicles. Comparing many internal combustion engine mid-sized vehicles, they create, on average, 150.4 g CO₂ eq per kilometre. This would mean that a mid-sized car with 100,000 miles would've produced approximately 24 million g CO₂ over its entire operation.

A. Vehicle production & decomposition

The production and decomposition of the combustion engine itself creates a smaller amount of pollution when compared to the carbon dioxide produced from the engine when operating. This is because, to create the engine itself, only the metal components must be formed and assembled. The metal components themselves are not particularly harmful to the environment. Internal combustion engine vehicles require approximately 10 million grams of CO₂ for their production and decomposition.

III. ELECTRIC BATTERY VEHICLE POLLUTION

A. Vehicle running pollution

To calculate the local air pollution damages of an electric vehicle driven in county, we assume that the vehicle is charged in county and that this increases the electricity load in the electricity region in which the county is located. The amount by which load increases per mile depends on both the efficiency of the electric vehicle and the ambient temperature (which affects battery performance). An increase in electricity load in a given region leads to responses by various power plants which in turn changes the emissions from these plants. We estimate these effects econometrically. In particular, we determine the relationship for each hour of the day between emissions of NO_x, SO₂, and PM_{2.5} at each power plant and electricity load in a given electricity region, controlling for load in other regions and month-of-sample fixed effects. The resulting marginal emissions factors show how emissions change at each power plant from charging an electric vehicle in county.

Most studies have considered CO₂ emissions to link GHGs with electric mobility. From the 65 articles that fulfilled the inclusion criteria, 51 reported results for CO₂ emissions. Fig. 8 indicates that EVs are associated with substantial reductions in CO₂ emissions. According to the literature reviewed, CO₂ emissions due to EV penetration are less sensitive to the variation of source of energy generation than particulate and gaseous pollutants. In other words, some studies have shown that even with a high percentage of electricity generated by coal powerplants, EVs may still reduce emissions of CO₂. For example, in China where the electric grid is mostly dominated by coal generation, BEVs can reduce CO₂ emissions by 20%, but increase PM₁₀, PM_{2.5}, NO_x, and SO₂ emissions by 360%, 250%, 120%, and 370%, respectively.

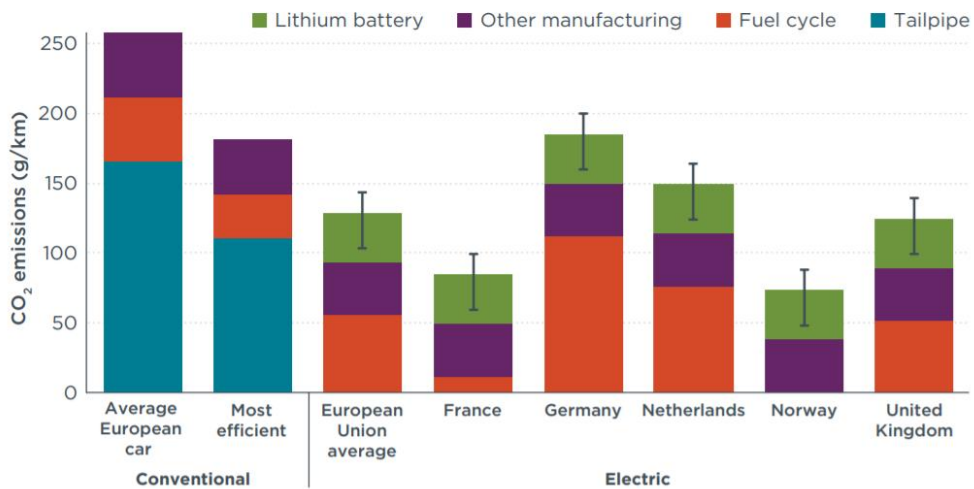


Fig. 4. Life-cycle emissions (over 150,000 km) of electric and conventional vehicles in Europe.

the life-cycle impact of a vehicle is the sum of the emissions impacts from all the associated vehicle’s activities: manufacturing, fuel cycle, and use. Electric vehicle manufacturing requires more energy and produces more emissions than manufacturing a conventional car because of the electric vehicles’ batteries. Lithium-ion battery production requires extracting and refining rare earth metals, and is energy intensive because of the high heat and sterile conditions involved. Most lithium-ion batteries in electric vehicles in Europe in 2016 were produced in Japan and South Korea, where approximately 25%–40% of electricity generation is from coal. On the other hand, electric vehicles travel farther with a given amount of energy and account for fewer emissions through the fuel production and vehicle use phases.

1. Factors Affecting the BEV

In-Use Stage for BEVs, the amount of GHG and other pollutants emitted during upstream processes are related to the fuel type and the energy efficiency of the power plant and transmission infrastructure used to power the vehicle. The amount of GHG and other pollutants emitted during downstream processes (i.e., vehicle operation) are related to the energy efficiency and other characteristics of the vehicle.

- Electricity generation mix
- Charging patterns
- Transmission efficiencies
- Engine efficiency
- Vehicle size and weight
- Driving style
- Auxiliary systems

B. Vehicle production & decomposition

Overall, electric vehicles typically have much lower life-cycle greenhouse gas emissions than a typical car in Europe, even when assuming relatively high battery manufacturing emissions. An average electric vehicle in Europe produces 50% less life-cycle greenhouse gases over the first 150,000 kilometres of driving, although the relative benefit varies from 28% to 72%, depending on local electricity production.⁴ An electric car’s higher manufacturing-phase emissions would be paid back in 2 years of driving with European average grid electricity compared to a typical vehicle. This emissions recovery period is no more than 3 years even in countries with relatively higher-carbon electricity such as in Germany. When comparing to the most efficient internal combustion engine vehicle, a typical electric car in Europe produces 29% less greenhouse gas emissions. We do not account for different driving or charging patterns in different countries; this is a rich area for future work.

1. Batteries

The lithium-ion batteries store the energy for fully electric vehicles. Lithium-ion batteries also allow the vehicle to travel up to 335 miles on one charge; the actual travel mileage depends on the vehicle model (Lambert, 2017). Lithium-ion batteries have come a long way since 1992 when they were first sold to consumers. They now hold double the



energy by weight and only cost 300 dollars per kilowatt-hour (Patel, 2015). When Tesla released the Roadster in 2008, the cost of a lithium-ion battery was upwards of 900 dollars. Although still expensive, this decrease has helped drive down the cost of fully electric vehicles. The reason these are the preferred batteries of choice is their “high power-to-weight ratio, high energy efficiency, good high-temperature performance, and low self-discharge” (US Department of Energy, “Batteries”, 2016). These factors make lithium-ion batteries the most promising form of on-board energy storage and management devices for fully electric vehicles. A variety of chemical designs for the lithium-ion battery are currently being tested and produced. The Nissan Leaf and BMW i3 use a lithium nickel manganese cobalt battery which has an energy density of 140-180 Wh/kg (Patel, 2015). The issue is finding a chemical make-up that allows for an increase in energy capacity while still being stable at high-temperatures and repeated charging cycles. Researchers are continuing to test new materials for lithium-ion batteries in order to increase their energy density for electric car use; vehicles will be able to go further on a single charge which will make them more practical for car owners. electric vehicles still produce less than half the amount of CO₂ as conventional gasoline cars does annually. The purpose of the study was to bring all the pieces of information together that create a full picture of the potential significance of this technology. While electric vehicles may be making a difference now, their impact could be increased if a substantial effort is made by the government and lobbying parties to encourage more policy change, research, and production of more electric vehicles.

2. *Grid decarbonization*

Electricity used in the battery manufacturing process accounts for roughly half of emissions related to battery production, so increased use of renewable energy and more efficient power plants will lead to cleaner batteries. The carbon intensity of electricity is expected to drop by more than 30% by 2030 in most markets that still have relatively high fossil fuel combustion.6 Decarbonization of electric grids around the world by an average of about 30% will result in approximately 17% lower battery manufacturing emissions by 2030.

3. *Battery second life.*

Automotive lithium-ion batteries provide an opportunity for reuse in stationary storage applications after their vehicle use phase. This, in turn, allows the initial battery production footprint to be spread across more use. When batteries are removed from electric vehicles after their first life, they are likely to retain significant capacity, typically 75%–80% of their original capacity. They could, therefore, play an important role in supporting the electric grid, especially as intermittent renewables become more widespread. A report from the National Renewable Energy Laboratory identifies utility-scale peak-shaving as the most promising opportunity for second life batteries. This market has favourable duty cycles and will likely be large enough to absorb the supply of used batteries for the foreseeable future.

4. *Battery recycling.*

As the electric vehicle industry grows, battery recycling also will become more feasible. Materials production is responsible for approximately half of the greenhouse gas emissions from battery production, and recycled materials typically have a lower carbon footprint than the same materials from virgin sources. For example, production of recycled aluminium creates approximately 95% less greenhouse gas emissions compared to producing aluminium from natural sources.

TABLE I
POTENTIAL REDUCTIONS IN GREENHOUSE GAS EMISSIONS RESULTING FROM IMPROVEMENTS IN
BATTERY MANUFACTURING AND USE

Development	Percent change in battery manufacturing emissions	Percent change in life-cycle g CO ₂ e/km
Larger electric vehicle battery	+33% to +66%	+18%
Battery second life	N/A	-22%
Battery recycling	-7% to -17%	-4%
Projected grid decarbonization	-17%	-27%
Greater battery energy density	-10% to -15%	-6%

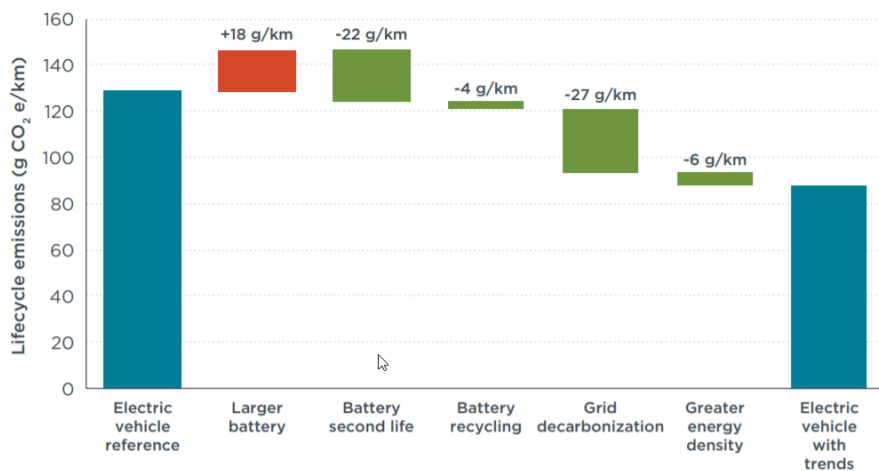


Fig.5. Potential changes in battery manufacturing greenhouse gas emissions (compared to reference 2017 electric vehicle) resulting from increased pack size and improvements in battery manufacturing and use.

IV. COMPARISON

A. CO₂ Emission Results of ICEVs and BEV

1. Well-to-Wheel Emission ICEVs

It was found that diesel vehicles emit less CO₂ than gasoline vehicles on average. Although the CO₂ emission is less on diesel vehicles for the same amount of fuel combusted, the fuel efficiency of gasoline engines is higher than the respective of diesel engines and, as a result, the required fuel for the combustion is notably less.

2. Well-to-Wheel Emission BEVs

According to the results extracted based on each country's generation mix, BEVs emit, on average, less GHGs than the corresponding ICEVs in most European countries. As the type-approval fuel and electricity consumption values result to underestimated CO₂ emissions, the countries in which BEVs' emissions exceeded ICEVs' were notably fewer according to the type-approval results compared to the in-use results. Hence, considering the type-approval consumption values, only countries with significantly higher ratio of fossil fuels refute to the emission reduction effect of BEVs.

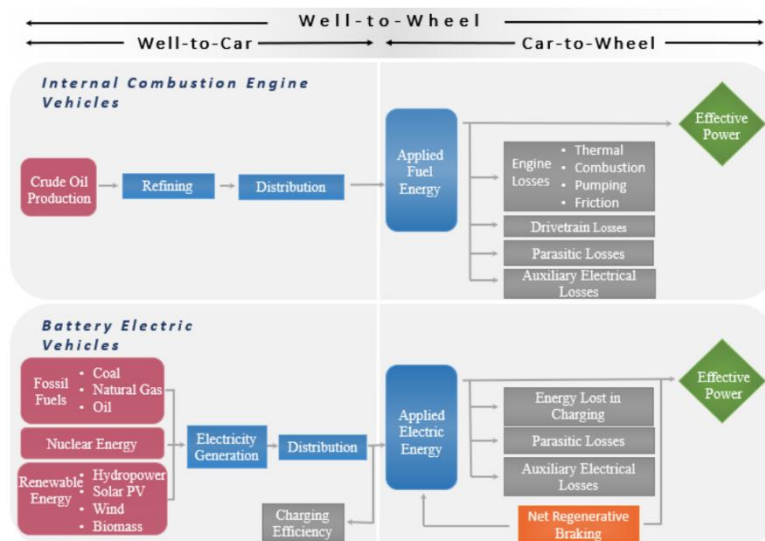


Fig. 6. Entire energy flow of ICEVs and BEVs

The internal combustion engine vehicle used approximately 3 times more energy than the electric vehicle. The comparison of a vehicle's energy consumption does not directly correlate with CO₂ production, because the energy is produced in different ways. However, this study does show how much more efficient electric battery vehicles are than internal combustion vehicles. A different study used a similar procedure and determined that internal combustion engine vehicles used 2.7 times more energy than electric vehicles.

IV. CONCLUSION

This study analysed the real-world contribution of BE and ICE vehicular technologies into air pollution from a Well-to Wheel perspective. The CO₂ emissions calculated considering the in-use consumption values were higher than the corresponding type-approval regardless of the vehicular category and technology. More specifically, the gasoline ICE models exceed diesel on the emission extraction. Regarding BEVs, in countries with high ratio of nuclear or renewable energy in their generation mix, BEVs are significantly more environmentally friendly than ICEVs. On the other hand, in countries with elevated ratio of fossil fuels, and especially coal and oil, BEVs emit marginally less CO₂ than ICEVs. Overall, both electric battery vehicles and internal combustion engine vehicles contribute to harming the environment. However, they contribute in different ways. Overall, electric battery vehicles contribute less to harming the environment than internal combustion vehicles. The future of all vehicles is to create more energy sustainable technology that is less harmful to the earth, and the best way to encourage this is to increase the number of electric vehicles on the road. Research must be done to improve the cost efficiency and lessen the environmental burden of the production of lithium ion batteries.

Electric cars are much cleaner than internal combustion engine cars over their lifetime. We find that a typical electric car today produces just half of the greenhouse gas emissions of an average European passenger car. Furthermore, an electric car using average European electricity is almost 30% cleaner over its life cycle compared to even the most efficient internal combustion engine vehicle on the market today. Plug-in hybrid vehicles, when driven on electric power for most trips, have lifecycle emissions similar to battery electric vehicles. In markets with very low-carbon electricity, such as Norway or France, electric vehicles produce less than a third of the life-cycle emissions of an average combustion-engine vehicle. This finding bolsters governments' goals to promote electric cars as part of their decarbonization strategies.

REFERENCES

1. Amphlett, J. C., Mann, R. F. and Peppley, B. A. (1995). Predicted emissions from a methanol-fueled electrochemical automobile engine base on a PEM fuel cell. SAE Paper No. 952374, also in SAE SP-1115; Alternative Fuels Emissions Technology, pp. 11–16.
2. BP. Statistical review of world energy. BP Magazine, June 2018, <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html> (accessed 7/2019).
3. Auto Tech Review. Internal combustion engine 4.0, <https://autotechreview.com/technology/internal-combustion-engine-4-0> (accessed 8/2019)
4. Ozturk, I. Measuring the impact of energy consumption and air quality indicators on climate change: Evidence from the panel of UNFCC classified countries. *Environ. Sci. Pollut. Res.* 2015, 22, 15459–15468.
5. Ang, B.W.; Liu, F.L.; Chew, E.P. Perfect decomposition techniques in energy and environmental analysis. *Energy Policy* 2003, 31, 1561–1566.
6. Amato, F., A. Karanasiou, T. Moreno, A. Alastuey, J. Orza, J. Lumbreras, R. Borge, E. Boldo, C. Linares, and X. Querol (2012), "Emission factors from road dust resuspension in a Mediterranean freeway," *Atmospheric Environment* 61: 580-587.
7. Archsmith, James, Alissa Kendal, and David Rapson. 2015. "From cradle to junkyard: Assessing the life cycle greenhouse benefits of electric vehicles." *Research in Transportation Economics* 52: 72-90.
8. Holland, S., E. Mansur, N. Muller, and A. Yates (2016), "Are there environmental benefits from driving electric vehicles? The importance of local factors," forthcoming *American Economic Review*.
9. Brady, J., O'Mahony, M., 2011. Travel to work in Dublin. The potential impacts of electric vehicles on climate change and urban air quality. *Transp. Res. Part D Transp. Environ* 16, 188–193.
10. Doucette, R.T., McCulloch, M.D., 2011. Modeling the CO₂ emissions from battery electric vehicles given the power generation mixes of different countries. *Energy Pol.* 39, 803–811.
11. Aslani, A., & Wong, K. V. (2013, September 28). Analysis of renewable energy development to power generation in the United States. Retrieved March 13, 2017,
12. Lambert, F. (2017, April 13). Tesla Model S 100D officially takes top spot for longest range EV with EPA 335-mile rating. Retrieved April 14, 2017



13. Fysikopoulos, D. Anagnostakis, K. Salonitis, G. Chryssolouris, “An Empirical Study of the Energy Consumption in Automotive Assembly”, 45th CIRP Conference on Manufacturing Systems, (2012), pp. 540-547
14. P. Stavropoulos, C. Giannoulis, A. Papacharalampopoulos, P. Foteinopoulos, G. Chryssolouris, “Life Cycle Analysis: Comparison between Different Methods and Optimization Challenges”, 48th CIRP Conference on Manufacturing Systems, (2015), pp. 626-631.



INNO  **SPACE**
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details