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Upgradation of IC Engine Vehicles to Electric Vehicles

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***Abstract*—** This paper aims to provide a solution to the rise in pollution and depletion of fossil fuels by reducing the use of IC Engine Vehicles and converting them to Electric Vehicles. Population rise has led to an increase in fuel consumption and thus faster depletion rate of fuel. The increase in fuel consumption is the leading cause of the emissions of polluting gases. The essence of this project lies in solving the problem of the fuel crisis in the near future along with mitigation of pollution, thus making our world a better place to live and helping in the "Go Green Initiative".

Keywords— Mechanical Engineering, IC Engine, Battery Electric Vehicle, Solar Energy

I. INTRODUCTION

Pollution and extinction of fuels are pressing concerns for our country and world. According to EPI (Environmental Pollution Index) 2018, India has ranked 177 out of 180 in curbing pollution. Our country was the 3rd highest to consume oil and 4th highest to contribute to greenhouse gas in 2015 and 2013 respectively, which means polluting more and less cleaning.

Given our country having millions of IC Engine Vehicles, it seems convenient to switch from IC Engines to Electric Vehicle. Indian Govt. has planned to shift from fuel-powered to battery-powered vehicle by the year 2030. And it is obvious that to pave the way to newer electric vehicles the older IC Engine vehicles may be scrapped. The prices of Oil is rising every day and the resource will virtually get exhausted in the upcoming years whereas, the total number of vehicles will increase to almost four times.

Figure 1. The rise in Automobiles has increased a lot of pollutions in a worldwide manner

Thus, having a conversion technology or a conversion kit for such vehicles might ensure a smoother transition and the IC Engines vehicles can be recycled into Electric Vehicles with such conversions. For smoother transition and upgradation, it is high time to act. According to a 2015 survey, there are 210 million (21 crores) registered vehicles in India. There is going to be a crisis in fuel in a few years ranging from 50-51years according to a survey. Vehicles of current technology will become obsolete soon. It is high time that we find ourselves an alternative so that we and our upcoming generation are privileged from this cleaner no emission technology.

Figure 2. Cities are filled with old IC Engine vehicles which are constantly polluting our environment

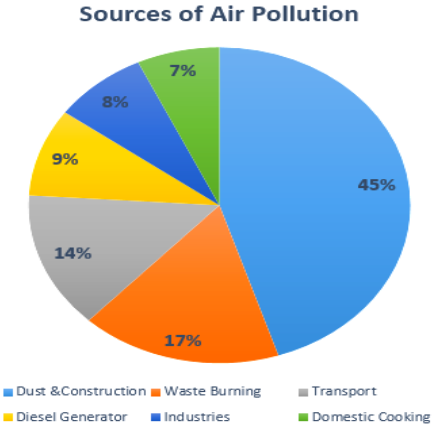

Figure 3. Worldwide Data Shows 14% Pollution occurs from Transportation

On an account of pollution burning, fuel causes the emission of nitrogen oxide, sulphur oxides, oxides of carbon. Hydrocarbons and many other particulate matters. Carbon dioxide is the principal product of combustion of fossil fuel as it accounts for 60-90% of the mass of fuel that is burnt. India holds a population of more than 13.5 million (135 crores in 2018) stands 4th in rank as a contributor to greenhouse gas and a rank of 177 out of 188 in Environmental Pollution Index, 2018 (EPI).

Figure 4. Electric Vehicles provides cleaner transportation (Electric bicycle FreeGo Hawk)

Converting an ICEV to BEV is done by selecting a suitable electric motor, battery, controller and other accessories necessary for the conversion kit. The main focus point of this paper is Two-Wheelers and Four-Wheelers. The further development can take place in Commercial Vehicle Segment– Buses and Trucks. Future works of this project include the integration of solar panels in suitable positions so that the battery can be charged in the absence of electric supply thus increasing the electric supply. This research area is never-ending as there will always be the scope of improvements if the motor and battery design can be compacted, it would reduce the vehicle mass along with power requirement.

Figure 5. A huge amount of Oil is burnt daily basis which generates a lot of Carbon Dioxide our atmosphere can take

Electric Vehicle (EV) lacks popularity as of now. Industries will need to invest in new technology which will start generating money after India makes the switch. Starting earlier will provide bountiful time for product development and troubleshooting. The challenging part of this project will be the cost optimization so that it encourages people to, "Go Green".

Nomenclature

ICEV- Internal Combustion Engine Vehicle
BEV- Battery Electric Vehicle
EV- Electric Vehicle
IC- Internal Combustion

Needless to say, it has increased a lot in the past years. It is high time to start working on the conversion technology as it would reduce the upgradation costing. This paper concerns about the pathway to the upgradation of IC Engine Vehicles to Battery Electric Vehicles for both two-wheelers and four-wheelers.

II. RELATED WORK

In a paper [3], "Converting an Internal Combustion Engine Vehicle to an Electric Vehicle", Ali Eydgahi and Edward Lee Long IV converted a four-wheeler (ICEV) into an electric vehicle. Delfim Pedrosa et. al [5] carried a similar research work with a four-wheeler in "A Case Study on the Conversion of an Internal Combustion Engine Vehicle into an Electric Vehicle". S.Vasanthaseelan et al [7] fabricated an electric two-wheeler using lithium-ion battery and with a motor.

III. METHODOLOGY

The conversion process of an ICEV to BEV consists of three major steps for both two-wheelers and four-wheelers:

1. ***Disassemble Mechanical System***
   Engine
   Gas-tank
   Heating & Cooling
   Preparing Chasis
2. ***Install Electrical Components***
   Electric Motor
   Controller
   Other necessary items
3. ***Install Power System***
   Battery
   Wiring
   Chargers

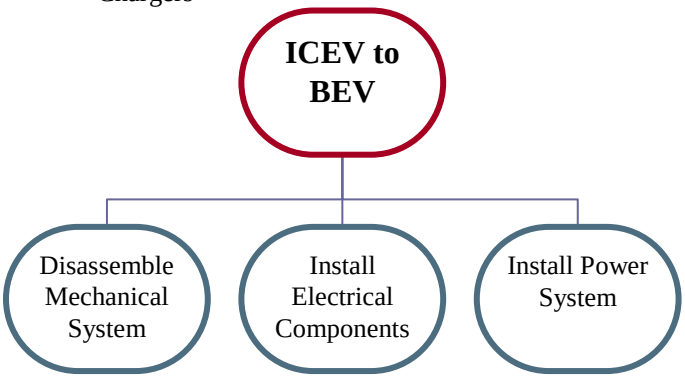

Figure 6. Conversion Process of IC Engine Vehicle to Battery Electric Vehicle

EV Components: Battery, Motor & Controller

In an EV, the basic components are Motor, Controller & Battery, i.e. the fuel. As mentioned before, EV consists of

a battery that provides energy and an electric motor which drives the wheel or axle. There is also a controller which would regulate the speed of the motor. Electric motors are made according to several specifications. They have a universal application ranging from clocks, cellphones (vibration motor) to fans air conditioners. The widespread use of this electric motor is due to its reliability. It has two basic parts: a rotor and a stator. And as we know, the less the number of components, the less wear and tear it will have. This works as an advantage over IC Engine as it has the only rotor as the moving part. Thus, theoretically, an electric motor which is made properly shall have a long life.

Figure 7. Battery: The New Fuel

The battery gives power to the motor which runs an EV. Lithium-ion batteries have a satisfactory specific power (W/kg) which is essential for storing energy and specific energy (W h/kg) which is essential in supplying this stored energy. The higher these two values are, the better. Lithium-ion is preferred over Nickel Metal Hydride (Ni-MH) because of the convenience regarding the cost.

The controller is one of the most important components of an EV as it governs the performance of an EV. It governs the motor speed, battery voltage, system current and yielding power and range. This controller is usually interfaced with the accelerator.

IC Engine has a lot of applications and advantages due to its popularity. But electric motors triumphs over IC Engines over hilly areas (lack of oxygen) by delivering the same power output all the time. This upgrade process can be divided into two categories as promised earlier:

A. Two-Wheelers

15% of the total population in our country use 2wheelers which is approx. 20.5crores. The main work would be to integrate the conversion kit and other accessories according to the existing drive system. A different model of two-wheeler will have a different drive design. Thus, by similar reverse engineering different models can be found out. Softwares like ANSYS or PTC CreO can be used to determine the design parameters and simulations can be run and a safe working model can be prepared.

Now in two-wheelers, the space available under the fuel tank can be utilized for installation of this conversion kit. The drive is to be given in the rear wheel. There might be a requirement of reverse engineering of the model to choose a suitable electric motor, controller and battery. If this conversion kit is prepared at a suitable price, many people will be encouraged to switch to EV.

An IC Engine operated two-wheeler was taken by Vasanthaseelan et al. and modified into a battery-operated two-wheeler. The following observations were made on the new components which were fitted in this two-wheeler.

Table 1: Specifications of Electric Bike

Specifications of Electric Bike (after Conversion from IC Engine)	
Battery	48V 10Ah
Motor	600W
Controller	Sinewave
Charger	3A
Charging Time	2hrs
Mileage	25-30km/hrs
Speed	25

B. Four-Wheelers

The accessories like the carburettor, ignition system, exhaust systems are to be removed and space can be utilized to fit electric motors, battery controllers and other mandatory accessories in it. Depending on the design and specifications of the vehicles, it is to be determined the amount of power required to run the vehicle. After deciding this, it is to be noted whether to use AC Motors or DC Motors as both have its advantages and disadvantages. Handling heavy machinery parts may require gantry or overhead cranes. These EV parts can be fitted according to convenience either in the front or the rear of the vehicle. The drive is also dependent on the location of the electric motor. It must be placed at an optimum position otherwise it will cause transmission loss and an additional cost of connecting the drive with the axle of the wheel.

The operating cost of these vehicles is cheaper than the fuel-powered vehicle on a long run. The Li-ion battery prices have decreased from $600 /kWh in 2012 to $250 /kWh in 2017 and are betting on a further drop to $100 /kWh in 2024 [1].

The mechanism which reduces the speed of a vehicle by conversion of kinetic energy into another is called regenerative braking. Shunt motor is as adaptable like a shunt generator. This property of similarity brings stability to a higher degree and make shunt motor very useful for regenerative braking applications either manually or electronically controlled the energy flow found in the BEV having regenerative braking is visible in the figure.


Figure 8. Hybrid Cars: For Unreliable Electric Supply Areas

The backbone of this upgrade process is efficiency, which must be considered from a grass-root level. The choice of battery, the mass of battery, the mass of other electrical components are all contributing factors towards the efficiency of such an upgrade. But once considered, it will enhance the performance of these EVs.

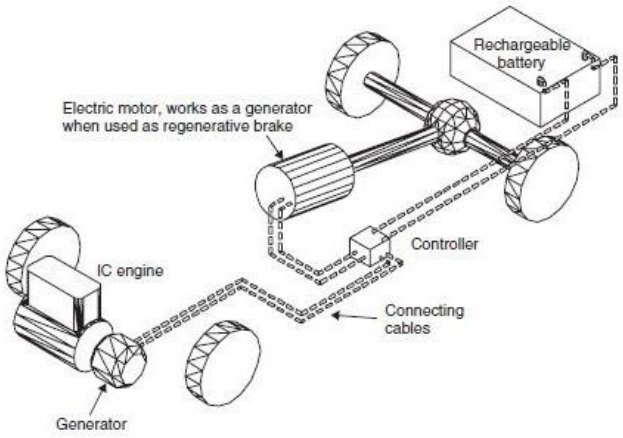

Figure 9. Hybrid Vehicle Layout (Series) with a rechargeable battery which can be charged from mains electricity

Attempts of electric vehicle launch have already been started in India and several models have been designed and made available. Companies are constantly trying to build a mechanism to make EV cost-effective. But the problem of pollution lies in old pieces of machinery that are currently in use. The conversion even if it is employed by companies can provide good exchange offers and speed up the transition at a minimal cost. This paper thus provides a solution and acts as a problem solver.

Figure 11. Battery Electric Vehicle GM EV1

On summing up, this upgrade process would primarily include the calculation part and the reverse engineering part of a chosen vehicle from two-wheeler section and a suitable electric conversion kit is to be calculated which will decide about the battery capacity, electric motor capacity, the controller and other necessary accessories as mentioned earlier. Then these accessories as mentioned earlier. Then these accessories will be bought and simultaneously fitted after removing the IC Engine and its components. A suitable housing needs to be prepared to keep the electric motor secure from damage and water does not enter the electrical parts. After successful integration, it will be tested for several parameters like charge capacity, expected life, maintenance cost etc. Then this similar procedure is to be transferred to another model. The entire focus on four-wheelers once the two-wheeler conversion kit is successfully implemented.

Table 2: GM EV1 Specifications

Body Style	**Two Seat, Two Doors**
Electric Motor	102kW, 3 Phase Induction Motor
Transmission	Single Speed (Motor and Differential)
Battery	Lead Acid 18.7kW (1) NiMH 26.4kW (2)
Range	112-160 km (1) 160-224 km (2)
Wheelbase (mm)	2512
Length (mm)	4310
Width (mm)	1765
Height (mm)	1283
Curb Weight (kg)	1400

Should we consider conversion (upgradation) or Purchase a New EV?

The necessity of converting the ICEV into BEV are discussed & supported by data in the following result & discussion section. A huge number of population uses ICEV & it will be convenient for users to have an option such a conversion. This will help the country to switch into EV quickly instead of putting a financial strain by pressuring users to purchase a new EV altogether.

IV. RESULTS AND DISCUSSIONS

In a survey done in 2015 by AD Little in the USA, it was found that the cost of IC Engine Vehicle is $47,676 while a battery electric vehicle is $ 68,492. The initial costing of BEV is more, but the maintenance of a BEV is 60% less than an IC engine vehicle.

Table 3: Costing of a compact vehicle ownership for 2015 mid-size compact ICEV vs. BEV

Category of Cost	**ICEV (in $)**	**BEV (in $)**	**BEV-ICEV (in %)**	**ICEV (% Total)**	**BEV (%Total)**
True Vehicle	19114	37865	70	36	43
Fuel-Petrol/Electricity	10447	4858	-53	20	6
Insurance	14485	17171	9	25	19
Financing	769	1862	88	2	2
State Fees	3184	5308	45	6	6
Maintenance and Repairs	5651	2251	-60	12	3
Home Charging Installation		1225			2
Battery Replacement		3244			3
Alternative Transportation		12070			15
Total	**47676**	**68492**	**44**	**100**	**100**

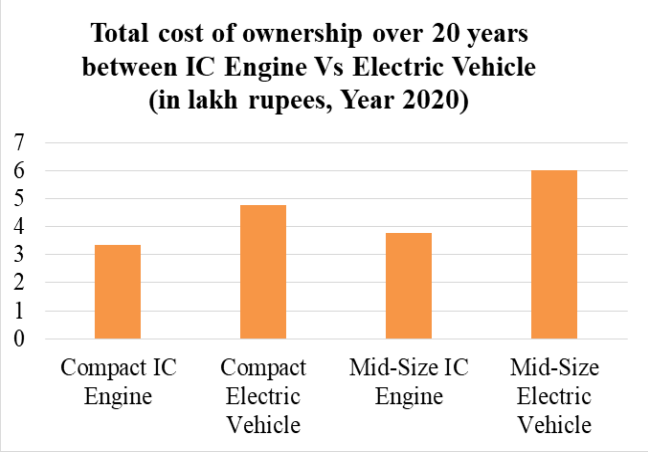

Figure 12. Total Cost of ownership over 20 years between IC Engine vs. Electric Vehicle (in lakh rupees)

Figure 12 tells us about the cost of ownership of over 20 years between the IC engine vehicle versus electric vehicle (in lakhs) which says a compact vehicle fitted with IC engine will cost around ₹ 3.2 lakhs while a compact electric vehicle would cost around ₹ 4.8 lakh while mid-size IC engine cost around ₹ 3.8 lakh and midsize be around ₹ 6 lakh.

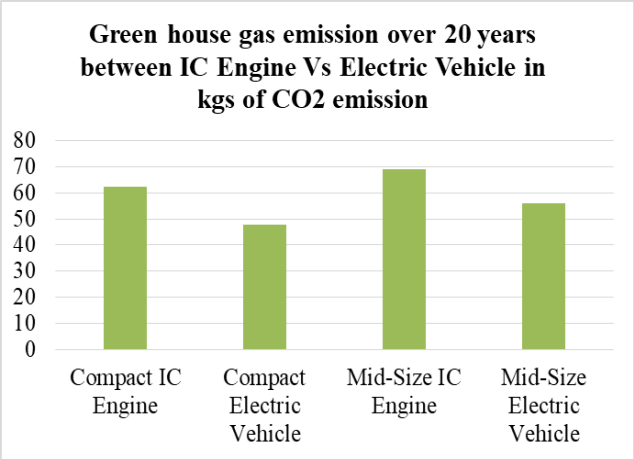

Figure 13. Greenhouse gas emission 20years between IC Engine vs. Electric Vehicle (in kgs) of CO2 emissions

Figure 13 shows the influence of IC engine vehicles and battery electric vehicle on greenhouse gas emission in 20 years. A compact IC engine vehicle emits around 61 kg of carbon dioxide while a compact electric vehicle emits around 48kg. A mid-size ICEV emits around 70 kg of carbon dioxide whereas a mid-size BEV around 55 kg of carbon dioxide.

Table 4: Power of battery and range

SL. No.	Specifications-2015	Compact Passenger	Mid-Size Passenger
1	Size of Battery (kWh)	24	36
2	Range of Driving (km)	120	164
3	Mileage (kWh/km)	0.2	0.264

Table 4 gives us an estimate of the power of battery the range of a compact passenger and mid-size passenger battery electric vehicle.

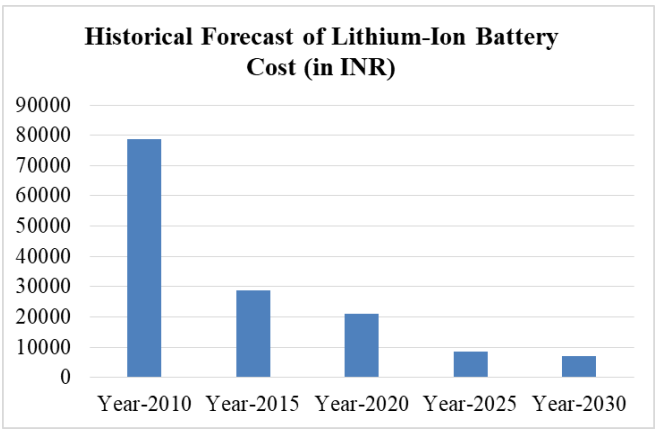

Figure 14. Historical Forecast of Lithium-Ion Battery Cost

Figure 14 has the data of the forecast of price of the lithium-ion battery, which has undergone drastically 75% in the past 10 years making it visible.

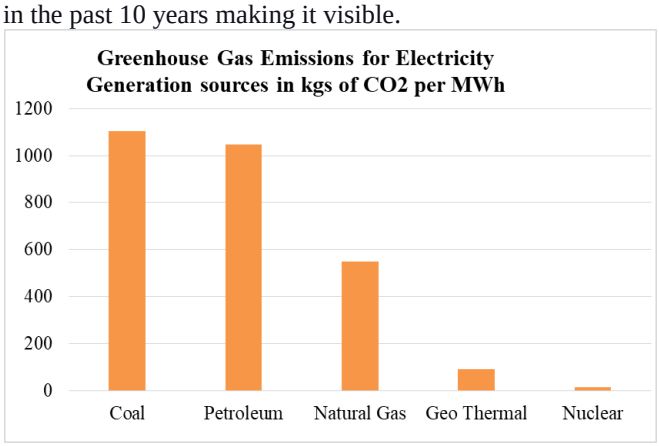

Figure 15. Emissions of Greenhouse Gas for Electricity Generation Sources in kgs of CO_2/MWh

Figure 15 represents the influence of Coal Petroleum and natural gas, thermal and nuclear electrical electricity generation source on the division of carbon dioxide.
Figure 16 gives us and Outlook of for a product in actual life versus in RandD in ICEV and BEV.

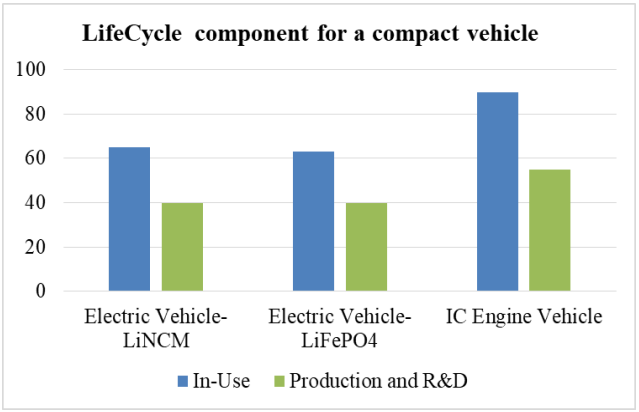

Figure 16. Lifecycle Component for a compact vehicle

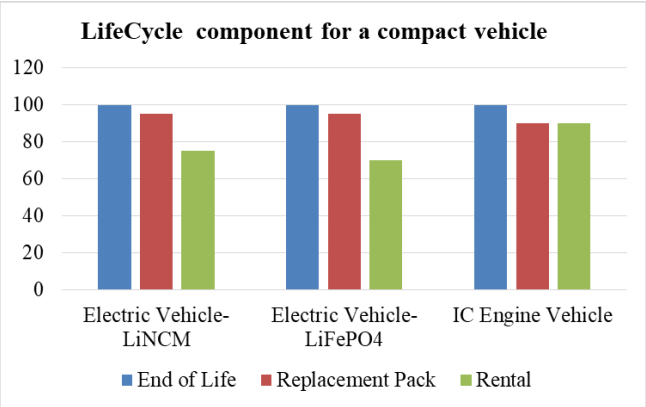

Figure 17. The lifecycle component for a compact vehicle

Figure 17 also gives us a comparison of electric vehicle (LiNMC and LiFePO4 type) with an IC engine vehicle and their end of life replacement pack.

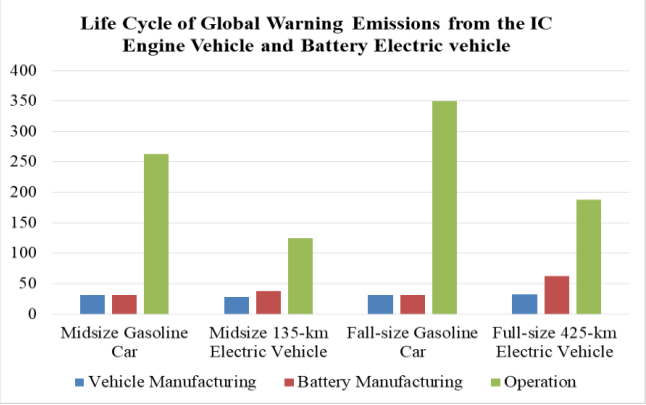

Figure 18. The lifecycle of Global Warming Emissions (gm of CO_2) from the IC Engine Vehicle and Battery Electric Vehicle

Figure 18 shows the emission of different kinds of the vehicle both ICEV and BEV it is found that an EV does for less emission compared to ICEV. It is also to note that even a full-size electric vehicle does less emission than a midsize ICEV.

V. CONCLUSION AND FUTURE SCOPE

From the Results Section, it can be concluded that it is justified that converting the ICEVs into BEVs are a more logical & cost-effective solution to the problems like fuel crisis, delay in bringing newer technology to developing nations & eliminate threats like old polluting ICEVs which are not maintained (especially in Rural Areas). It is also to note that:

1. *ICEVs are harming the environment by 16% more emission of Global warming gases CO_2 compared to BEVs.*
2. *ICEVs are 44% cheaper than new EVs whereas if converted this can be reduced a lot & can be made feasible.*
3. *The trend of Battery cost suggests that over the years the cost of BEVs will become more feasible & thus a viable option for every user.*

Electric vehicles a few years earlier were an option, even though a costly one. But as the days towards the next decade are approaching, it is becoming a necessity both pollution-wise and fuel-crisis wise.

It is only a matter of time when people will master this new technology and will adjust to the changes. As engineers are constantly trying to make life easier, this challenge that our country faces shall be solved too.

EVs are the upcoming newest technology that the next generation will cherish. And if conversion technology leaps, it will be effective in a worldwide manner, thus curbing the problem of pollution, hence global warming at a budding stage. It would be exciting to join hands and work for our country India and make it a better place by inventing something useful.

There are scopes of improvement of this upgrade process in future as it will include solar panels attached to the body of the electric vehicle which will constantly contribute a charge and thus elongate the charge retention timing.

Figure 9. Commercial Uses like trucks and buses are one of the topmost contributors to pollution

As mentioned earlier, there will always be scope to increase efficiency if light-weight components are incorporated into the system.

Soon, lots of battery producing companies will resurface and will ensure cost reduction. These will contribute to the overall price drop in EV, making it feasible for a certain range of people. It can also be successfully integrated into existing buses and trucks i.e. commercial areas, where emission is much higher and toxic. This upgrade has a direct industrial application in the long run.

ACKNOWLEDGEMENT

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