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Research Paper

Electrification of 4-Wheel Sector

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ABSTRACT

This paper presents scopes and possibilities of electric vehicles if it is made to substitute fossil fueled 4 wheelers completely from its arena. The common consumers are still not onto electric vehicles due to various reasons like cost, charging facility and their power requirements. This work will show comparison of cost, energy efficiencies, emissions and pollution involved, maintenance and service requisites and last but not least the afterlife of both the vehicles.

Like well to wheel analysis of conventional fuel vehicles, here, grid to wheels analysis will be used for electric vehicles taking Kerala as reference location for study. The selected location has several power generation sources like hydel, thermal and wind energy. Different scenarios are considered to conduct the grid to wheel analysis. Here, battery electric vehicles (BEV) will be considered as replacement which will be categorised as (i) Lead acid battery and (ii) Li-ion battery. Supercapacitors are also used with lithium ion batteries so as to obtain faster charging, discharging while acceleration and braking. In this paper, the amount of electric power that must be produced additionally for the infrastructure of BEV's will be calculated.

A general study tells that energy is lost in ic engines at a very higher rate than electric vehicles in the form of heat. EV's have an efficiency of 77% when converting electric power from grid to wheels but combustion engines have efficiency of only 20-25% while converting chemical energy into mechanical energy. Interesting conclusions were also seen when emission and carbon footprints were compared. There are also some conclusions which reveal the difficulty of recycling the lithium-ion battery after its life. The processes aimed to recycle these batteries tend to produce extensive amounts of waste and emit greenhouse gases. But lead acid batteries are seen to be environment friendly as the majority of lead in this battery can be recycled. Different maintenance and services needed were discussed and compared with that of ICE vehicles. Many advantages and challenges were brought out while complete electrification in the 4 wheeler segment, and with the infrastructure growth, the target of zero emission vehicles can be obtained.

KEYWORDS: Battery electric vehicle, internal combustion engine, emission, energy efficiency.

Introduction

Several nations have started adopting EV's to cope with the fossil fuel scarcity and the overall increase in carbon emissions. It has started in India too, but will take time due to the reluctance of consumers to switch to a new technology. This reluctance is mainly due to the unawareness about the efficiency of EV's and lack of infrastructure available. The infrastructure and charging facilities will grow in quick time, but for an initial start, consumers should know about the efficiencies of EV's in various aspects.

For that, we are conducting a study in which we are considering an environment where 4 wheeled IC engined vehicles are completely substituted by EV's. We are selecting Kerala as the reference location because the state has its own various sources of electricity.

Firstly, let's look at the electric power generation and vehicle population in the state of Kerala.

The installed capacity of Kerala as on 01-12-2019 is 2823.01 MW in which 2224.5 MW (78.6%) is produced by KSEB, 287.946 MW (10.2%) from central share and 316.76 MW (11.2%) from private sector. Here, hydel power provides 70 percent power of 2052 MW. The daily energy demand of electricity in the state is approximately 81.07 Million units (MU). The population of 4 wheelers in Kerala is 21,78,000. We will find out if this amount of EV's can be accommodated by the energy production in Kerala.

The comparison of situation when electric vehicles replace IC engined vehicle can be conducted by considering some factors which are:

1. Energy Efficiency
2. Cost
3. Emission
4. Service and Maintenance

Energy Efficiency

Some calculations are worked out which compares energy efficiencies of electric vehicles, petrol and diesel cars. For that current ev's are considered and categorised into:

(a) Light EV's
(b) Medium Sedan EV's
(c) Heavy EV's

(a) Light EV's: In this category, we are taking the Mahindra e20 plus which is a small 4-seater hatchback EV. It had mainly 3 variants which used 11kwh in 2 models and 15kwh Li-ion battery in 1 model. The battery had a total battery capacity of 210 Ah. It's driving range is found to be 140km. The average consumption is said to be 88 Wh/km. If we consider the efficiency of e20 plus as 80% and energy transmission efficiency in the state to be 83%. So we can calculate the consumption as energy required to drive 1km= 88/(0.8*0.83)=132.53 Wh/km. Whereas small IC engined vehicles use upto 900 Wh/km.

(b) Medium Sedan EV's: As a reference, we are picking Mahindra eVerito which is a 5 seater sedan EV. This vehicle uses 21.1 kWh Lithium-ion batteries having 288 Ah total storage capacity. Driving range is certified by MIDC as 181km. The average consumption of energy is provided as 163.63 Wh/km. So taking the same efficiencies as before, the energy required to drive 1km will be = 163.63/(0.8*083)= 246.43 Wh/km. However, the Mahindra Verito(petrol version) uses 871.44 Wh/km.

(c) Heavy EV's: In the SUV section, we select Morris Garages Zs EV which is a 5-seater SUV. It has a 44.5 kWh powered Li-ion battery. The vehicle provides a range of 220km in real-drive experience. The average consumption of energy is 193 Wh/km. Considering the efficiencies, the overall consumption from well to wheel per 1km will be = 193/(0.8*0.83)= 290.66 Wh/km. The MG Hector petrol version uses 1052.44 Wh/km.

From the given data, we can analyse that EV's use very less amount of energy as compared to ICE vehicles.

If we take the average of battery capacities of EV's in each category, we can assume an overall Battery capacity needed as 25 kWh, we can calculate the approximate of daily energy needed using the vehicle population in the state i.e multiplying battery capacity with car population = 25 × 21,78,000 = 54.45 MU. As we have mentioned above the daily demand is 81 MU. So the state can accommodate some energy demand but should plan to generate more power or to enhance the current generation.

Cost

The running cost for BEV's is much lower than conventional vehicles due to the high efficiency drive train. For instance, in the case of Nexon EV, a full charge (0-100 per cent) consumes approximately 30 units of electricity over eight hours. With domestic electricity rating at about Rs 5 per unit (tariff in Kerala state), it works out to about Rs 150 for a full charge. This means that this vehicle can go 200 km for 150 rupees, to be more precise, only up to 1.3 Rs per km. However, the same size and power petrol vehicle (Nexon) costs 18 kmpl, and the average petrol price in Kerala is Rs 102.6/l. The vehicle has a tank capacity of 44 litres. So the vehicle for travelling 792 km will cost Rs 4514.4. This will result in approximately Rs 6/km.

However, the initial prices of electric vehicles are significantly higher than that of conventional vehicles, mainly because of expensive lithium-ion batteries. The average cost of lithium ion batteries used in BEV's are Rs 2.27lakhs whereas lead acid batteries cost Rs 52000 but were abandoned due to high charging time and lower life. However, battery prices have continuously dropped during recent years. The Kerala government has also signed a declaration of interest with Toshiba for technology transfer and mass production of lithium-ion batteries.

Interoperable and vendor neutral Public Charging Infrastructure capable of meeting the requirements of manufacturers will be provided in the state. Battery Swapping Facility, Public Charging Stations and Bulk Charging Stations must be provided phase by phase in different cities of the state. For instance, the first phase will include Thiruvnanthapuram, Ernakulam and Kozhikode, then subsequently transfer to other cities. Ideally in major cities, a charging facility should be available in every 3km × 3km grid. Also, charging stations should be set up every 25 km on the sides of highways and major roads connecting major cities. However, the operators of charging infrastructure will have the option to meet the power requirement from renewable or conventional sources or from Distribution Companies within the state.

Emission

The CO_2 emission in Kerala was estimated to be approximately 20 million metric tonnes from the transportation sector. CO, particulate matters and nitrous oxide emissions are also high in many parts of the state. Studies infer that even 30-40 % electrification in the transportation sector of Kerala can drop the overall emission content of India. The main advantage of EV is that it does not have direct emissions from the vehicle.

On the other hand, if we consider the pollution from the generation of electricity and production of the vehicle we can see some barricades. Electricity production through fossil fuel dependent methods will have 15-20% more emissions due to increase in the demand of electricity. Also, mainly batteries used are Li-ion during the production of which includes the excavation of lithium and cobalt causing additional environmental harms.

Main issue arose regarding the consideration of thermal power plants as the electricity generation source. But this argument can easily be handled if the major source of electricity is produced using Hydel power, which in Kerala is 2052 MW (71%) of total production in the state. Thermal power produces 676.56 MW (23%), Solar energy produces 134.117MW (4%) and Wind energy produces 60.28 MW (2%) of the total production. Also processes like refining of oil are needed in conventional vehicles which use large amounts of electricity are not required in the case of BEV's manufacturing.

Maintenance and Servicing

From the practical experiment on Nexon EV, it needs Rs 25,152 in maintenance over a five-year period which is about 40 per cent less than that of a combustion-engined Nexon.

The reduction in maintenance of BEV's are due to:

- Batteries, motors and related electronics require almost no routine electronic maintenance
- There are less fluids like motor oil that require regular maintenance.
- Number of moving parts are lesser.

There has been a concern above fatal burning of batteries during accidents. As we have seen in the calculations, batteries and charging systems in EVs work at a voltage ranging from 200-600 Volts. So, during accidents it might be dangerous but nowadays the Li-ion batteries come in a tight case and many tests are conducted in an environment in which the batteries undergo phenomena like charging, cold climates, short circuits, heating, accidents and submersion in water. A system must be devised such that all high voltage electric components must shut down and insulate during any mishap. As the EV's are heavy, their center of mass is much lower making them more stable and prevent roll-over.

The State Government shall establish centers of innovation and excellence for various components of BEV's including battery technology, drive train technology, software developments and charging technologies. Specific skilling programmes should be delivered hands-on learning for graduates and professionals related to EV's.

Conclusion

This study presents a comparative study of energy consumption, emissions, maintenance and other factors of BEV and ICE in Kerala and quantifies various practical possibilities for full BEV adoption. Using the WTW approach, we have identified the energy efficiency and emission profiles associated with different mixes of electric and EV penetration in Kerala.

In view of Kerala government's electric vehicle policy that by 2022, 10 Lakh fleet in Kerala will be electric as it is eco-friendly, cheap and replaces fossil fuels. Departments are encouraged to switch to electric mobility from gasoline or diesel vehicles to rental/lease vehicles for business purposes.

It can be seen that the projected approximate need of 54.43 Million Units (MU) per day is less than the current daily fluctuation in energy demand of KSEB (average daily energy demand is about 70 MU) and can easily be met. KSEB has already initiated steps to enhance the transmission capacity for bringing more power from the national grid foreseeing future demand. Till recently Kerala has been depending solely on hydro-power for electricity, and on other fossil-fuel alternatives from outside the State. But now, to cater the increasing demand of power on a long-term basis, encouragement is being given to power generation from non-conventional Energy Sources, which are environment friendly. Steps are being taken to increase the Renewable Energy component in the energy Sector by efforts like expediting the Renewable Energy projects currently underway, thereby increasing the clean component of the State's energy basket. Long term energy needs for electric mobility would be determined by the pace of conversion to electric as well as the projected vehicle population. These in turn depend on a variety of factors including technology, battery cost, government policy, penetration of public transportation, change in consumer preferences, economic growth, etc. Thus, accurate assessment of energy requirements for the long term is challenging.

Still BEV's emit few pollutants which can be controlled. But infrastructure construction and the price affect popularization of electric cars. With mass production, the price of BEV's will become more competitive. It is a promising pathway to substitute gasoline vehicles where electricity is generated from renewable sources in the mid-term period.

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