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The Techno Economic Analysis of Battery Operated Vehicle

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ABSTRACT : *In the present work, the techno economic analysis of battery operated vehicle has been carried out. The causes of low adoption of such vehicles in the rural the areas have been found. The green house gases emissions using such vehicles is also determined .In order to reach emission reductions of 80% or more, the emissions from the transportation sector have to be reduced by 25%-75%.One approach to achieving such reductions has been through electric, hybrid, or plug-in hybrid vehicles. One of the main challenges to producing cost-effective vehicles of these kinds has been to produce inexpensive, reliable batteries that can mimic many characteristics of internal combustion engines. In India, the battery operated vehicles mostly used have been two wheelers viz. scooters driven by direct current motors .For the present case study of a battery operated scooter was used for transportation. The battery operated vehicles are also at airports, zoos, public transportation, industries for material handling, domestic etc. Analysis shows that the battery operated vehicle has been proved more economical when compared with the motor cycle when the distance of travel has been increased.*

Keywords - *Battery operated vehicle, Hybrid vehicles, Direct current motors, and internal combustion engines*

I. BATTERY OPERATED VEHICLE (BOV)

Batteries operate electromechanical systems viz. dc motor that can deliver electric power at the desired time. In the battery operated vehicle the secondary batteries are used as they amenable to charging, high delivered energy, capable of yielding high energy for sustained period, high electrochemical power efficiency and they functions for long cycles of charging and discharging. The secondary batteries in common uses today are: lead-sulphuric acid type, nickel-iron with alkali type, nickel-cadmium, nickel-zinc, lithium alloy-metal sulphides type etc. Lead-acid batteries are comparatively cheap, have good endurance and are therefore widely in use.

II. LEAD ACID BATTERY

In the battery operated scooter sealed maintenance free lead acid battery has been used. A lead acid battery is built up of several small cells. The cell plates are made up of lead and the electrolyte is sulphuric acid of specific gravity 1.3.The plates are separated in a cell by means of separators which are porous in nature and electrically non-conducting. The positive plates are made up of lead core coated with lead peroxide and the negative plates with lead core coated with sponge lead. The lead core is hardened lead and antimony (3%) alloy. The battery is a combination of six cells each of 2 volts capacity in series, and hence offers 12 volts of electric power. In the battery grid, the core lead is coated with either sponge lead or lead-antimony hardened alloy. Several batteries can be linked in series or parallel or both ways depending upon the requirement of current. The input of the battery bank is fed by direct current of 5 amperes at 59.4 volts via a smart charger which can be connected to 220 volts and 50 hertz supply. For full charging, 6 to 8 hours is needed. The battery operated scooter used in this case study employs four batteries of 12 volts rating which are connected in series. The voltage required for driving the brushless direct current motor which has been attached to the wheel of battery operated scooter is 48 volts.

III. OPERATION OF BOV

The battery is the main source of energy for driving the vehicle so there has been need to understand the operation of battery .The battery electrolyte ionizes into H+ and SO4-ion drawing the current from the battery. The SO4-ions slowly settle at the negative plate, extract lead from sponge coating and becomes white lead sulphate, PbSO4.Similarly the H+ takes off oxygen from the lead peroxide at the positive plate, forms water, resulting in the formation of coated lead sulphate. Thus at both the plates, the white PbSO4 sets in .This is the discharge pattern of the battery on drawing the current. On account of formation of water, the strength of sulphuric acid falls down below 1.3.Also the original cell voltage which was at 2.2 volts diminishes to about 1.7 volts after the current is drawn.

During the recharging process, the strength of sulphuric acid has to be stepped up to a density of 1.3 again, and the voltage of the cell to be raised from 1.7 volts to 2.2 volts by passing a direct supply in the electrolyte and

reversing the discharge process. The ions H+ and SO4- are thus created in the electrolyte and the H+ ions attract the SO4- ions from the PbSO4 which is already present in the bath (generated during discharge)at the positive and negative plates. As this process takes place, the positive and negative plates revert back to the coatings of PbO and sponge lead respectively and the cell would be in a completely charged condition to supply power again. The lithium batteries which are used for the mobiles and transportation are lithium metal anode batteries and lithium ion batteries respectively. The Li-ion batteries are going to substitute the batteries used in present automobiles in near future. But due to the problem of thermal runaway there uses is limited in the transportation sector. The zinc bromine liquid batteries are used for stationary applications and not for automobiles. The lead acid batteries, which will likely improve but not sufficient to power a fleet of electric batteries; and nickel cadmium batteries, which have toxicity issues and not likely to provide sufficient power. When the batteries are put to use constantly, the discharge and recharge processes regularly occur. The life cycle of a battery is this 'number' wherein electric power has been drawn from a full charge to total discharge. If this number is highly rated, the battery is a superior system. In the course of routine work, the discharge rate is not allowed to go beyond 80%, that is, the battery power will not be allowed to fall below 20%.At the same time excessive recharging above 80% of the effective power also is not desirable. Therefore the battery would be in a fit condition between 20-80% of its discharge rate and 20 up to 80 percent of its recharging rate. In automobiles, the battery is generally not allowed to discharge below 50% as a precaution. It is possible to determine the life cycles of battery in an automobile and access its performance. The rating is expressed in terms of the current strength inherently stored in the battery. It is expressed in units of ampere- hours (Ah). At lower rates of electric discharge, the supply of current is steady. Battery rating is also dependent on the mass of lead present in it. The more the content of lead in the battery, the more it can store the amperes. The electrochemical energy in a battery is expressed in terms of kilowatt hours which is calculated as follows

$$KW = Ah\ (rating) \times Voltage/1000$$

This calculation will be used when battery power has been used to augment other types on non conventional energies whose availability is intermittent such as solar, wind etc.

IV. FORECASTING OF BOV DISSEMINATION

In the Fig. 1., there is an increase in the sales of vehicle in June-July every year due to the opening of schools and colleges showing that it is preferred by the people who are in the age group (18-20 years).There is increase in the month of October every year showing that the festival also increase the sales. In the month April-May every year there is increase due to opening of different schools also increase the sales. The decrease in the sales in October 2010 is due to coming of new competitor of the same brand of BOV as sold by the sole dealer in the city.

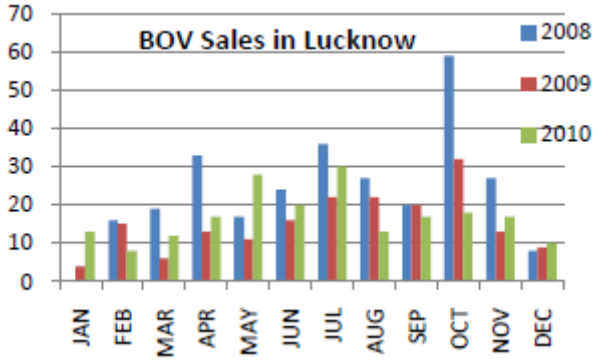

Fig.1. Battery Operated Vehicles (Scooter) sales by main dealer

V. TECHNO ECONOMIC ANALYSIS OF BOV IN RURAL AREAS

The petrol driven motor cycle and battery operated scooter has been considered for the techno economic analysis and analysis has been done as per which two wheeler is more suitable for the rural and urban areas and for the country as a whole. The comparison of the two wheelers has been predicted in the Table 1. Analysis

shows that the battery operated vehicle has been proved more economical when compared with the motor cycle when the distance of travel has been increased.

Choice of two wheelers in Urban/Rural areas is shown in Table. 2

TABLE 1.

	Motorcycle (MC)	**Battery Operated Scooter (BOV)**	**Preferred by Urban(U)/Rural(R) People**
Speed	High	Medium	MC(U&R both)
Load Capacity	High	Medium	MC (R)
Fuelling/Charging Time	Low	High	MC (R)
Body of two wheeler	Robust	Less Robust	MC (R)
Gradient Run	Less Time	More Time	MC(U&R both)
Technological Know how	More	Less	MC (R)
Reliability	More	Less	MC (R)
Servicing	Easy	Not Easy	MC (R)
Dealer	More	Less	MC (R)
Fuelling/Charging Station	Easily Available	Not everywhere Available	MC (R)
Fuel Cost	More	Less	BOV (U &R)
Noise	More	Less	BOV (U &R)
Pollution	More	Less	BOV (U)
Battery Life	-	Less	BOV(U)

(Source:Self Survey)

TABLE .2 Choice of two wheelers in rural areas

Total no. of two wheelers	Very High
No. of Motor Cycle	Very High
No. of BOV(Battery Operated)	Very Low
No. of Scooter (Petrol)	Very Low

Techno economic analysis of BOV and Motor Cycle for different distances of travel is explained in TABLE .3.

VI. CONCLUSIONS

The limitation of the batteries restricts the fast diffusion process of the battery operated vehicle in the rural and urban areas. Firstly, they do not last for a long time so there is a need of replacement again does not make the vehicle cost effective. Secondly, there is less awareness about the battery charging and discharging process which is the main cause of lessening of life of the battery. The performance of the battery depends on the current at which it is charged and discharged, and the depth to which it is regularly discharged. In this thesis, the battery operated vehicle discussed is a scooter which uses sealed batteries which does not need distilled water .In these batteries the extreme overcharging may cause mechanical damage within the cell and may raise the concentration of acid to the point where the ions are not mobile enough to allow the battery to work. Frequent cycles of charging and recharging leads to mechanical damage. In such conditions, occasional deep- discharging may reactivate the battery. The overall conclusion is that charge/discharge control is essential for long battery life; at least charging at constant voltage and at best having a sophisticated controller allowing de-stratification

bubbling, controlled charging and discharging currents, voltage cut offs, low internal resistance(<0.1Ω) and, perhaps occasional deep-discharging thus making the battery operated vehicle cost effective, reliable, long life and optimum performance. The diffusion of the battery operated vehicle is not disseminating in the rural areas as compared to the urban areas in Lucknow due to the technical and social reasons as discussed in the previous section. The payback period of the battery operated vehicle is two year respectively when distance of travel is 40 kilometer daily. So it will be mostly preferred for distance exceeding ten kilometers. There is a need of charging station after every ten kilometers. There is a need of increasing the improvement of battery technology in India so as to make battery which could be charged in less time and have less cost and which has larger charge density. Then the adoption of the battery operated vehicle will increase in the country and will help in GHG reduction. One litre of petrol emits 2.33 kilograms of carbon dioxide in the atmosphere. Each motor cycle emits minimum green house gases emissions of 93.2 kilograms per annum.

TABLE .3. Choice of two wheelers in Urban/Rural areas

	Motorcycle (MC)	**Battery Operated Scooter (BOV)**	**Preferred by Urban(U)/Rural(R) People**
Speed	High	Medium	MC(U&R both)
Load Capacity	High	Medium	MC (R)
Fuelling/Charging Time	Low	High	MC (R)
Body of two wheeler	Robust	Less Robust	MC (R)
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Dealer	More	Less	MC (R)
Fuelling/Charging Station	Easily Available	Not everywhere Available	MC (R)
Fuel Cost	More	Less	BOV (U &R)
Noise	More	Less	BOV (U &R)
Pollution	More	Less	BOV (U)
Battery Life	-	Less	BOV(U)

(Source:Self Survey)

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