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# Study on the implementation of Hybrid Two wheelers in the Indian Market

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**Abstract -** *The current world scenario is such that fossil fuels have become scarce than ever and alternatives to fossil fuels have become a necessity rather than an option. Hybrids, as such, have become the bridge between the usage of fossil fuels and the electric future. Hybrids have been around for over a decade, but in the form of four wheelers. Implementation of hybrids in two wheelers has been challenging and no definite solution has surfaced as of yet. Construction of a plausible hybrid system that comes at a very low expense on the existing commercially accepted combustion vehicles is a problem at the forefront of major automotive giants.*

***Key Words***: Hybrid, Efficiency, Customer Requirement, Indian Market, Automotive, Performance

## 1. INTRODUCTION

Hybrids have become a necessity in the current world automotive scenario. Fossil fuels have served as the primary source of power for automobiles over the years. The constant reminder that the fossil fuels are diminishing at an unprecedented rate has posed a challenge to the automotive future. Although electric vehicles may seem like the solution to the problem of depleting fossil fuels, the various issues with the implementation of electric systems restricts it from being so. The sheer cost of the vehicles and establishment of refueling stations have rendered the use of electric vehicles a concept than reality. Hybrids are relatively much easier to implement as they are more of a modification to the existing combustion system than an entirely new concept. Hybrids have been successfully implemented in four wheelers for over a decade now. The two-wheeler scenario is on the other hand, facing a lot of problems trying to cope with the percentage of increase in the cost of implementing a hybrid. The cost of implementing hybrids into two wheelers is much lower than in four wheelers but the percentage increase in the market value of a vehicle is higher in two wheelers, which leads the customers to believe that the two-wheeler hybrids are unreasonably priced.

### 1.1 Hybrid Vehicles

Hybrid vehicles, by definition, are vehicles that have two or more different power sources. Hybrids are the future of the current automotive scenario. With the depletion of conventional fuels, it has become a necessity to opt for a feasible option. The hybrid concept provides just the solution for the problem. They manage to improve fuel economy whilst giving excellent performance.

The dependence on oil as the sole source of energy for passenger vehicles has economic and political implications, and the crisis will inevitably become acute as the oil reserve of the world diminishes. The number of automobiles on our planet doubled to about a billion or so in the last 10 years. The increasing number of automobiles being introduced on the road every year is only adding to the pollution problem. There is also an economic factor inherent in the poor energy conversion efficiency of combustion engines.

Alternative fuels have become of utmost importance in the current world scenario. But the sole reason that alternative fuels cannot replace the entire gasoline situation at a time renders the use of these fuels useless. Climate change has become a major concern as of late. Global warming has become a global threat, bringing the question of using combustion vehicles to the forefront. As such, hybrids have become the go-to for saving the now-dying world. If not acted upon soon, the situation may go out of hand. This is exactly where hybrids come of utmost importance. Electric vehicles may be the permanent solution to the problem, but electric vehicles are not an immediate solution. Hybrids, thus, become the bridge to establishing a solution.

When the term hybrid vehicle is used, it most often refers to a Hybrid electric vehicle. These encompass such vehicles as the Saturn Vue, Toyota Prius, Toyota Yaris, Toyota Camry Hybrid, Ford Escape Hybrid, Toyota Highlander Hybrid, Honda Insight, Honda Civic Hybrid, Lexus RX 400h and 450h and others. A petroleum-electric hybrid most commonly uses internal combustion engines (using a variety of fuels, generally gasoline or Diesel engines) and electric motors to power the vehicle. The energy is stored in the fuel of the internal combustion engine and an electric battery set. There are many types of petroleum-electric hybrid drive trains, from Full hybrid to Mild hybrid, which offer varying advantages and disadvantages.

A vehicle is a hybrid if it utilizes more than one form of on-board energy to achieve propulsion. In practice, that means a hybrid will have a traditional internal-combustion engine and a fuel tank, as well as one or more electric motors and a battery pack. Hybrid cars are sometimes mistakenly confused with electric vehicles. Hybrids are most often gasoline-burning machines that utilize their electric bits to collect and reuse energy that normally goes to waste in standard cars. Theoretically, diesel-electric hybrids would be even more fuel-efficient, but hybrid systems and diesel

engines both represent extra cost. So far, installing both in the same vehicle has proven to be prohibitively expensive.

### 1.2 Electric Vehicles

The basic necessity for the implementation of a new method of transportation is its adaptability to the existing scenario. Such is not the case with electric vehicles. With the introduction of electric vehicles recently into the commercial market, problems are imminent. The sheer cost of the vehicle is overwhelming to the common man. There is a paramount change in the cost of living to accommodate the luxury of owning an electric vehicle. Due to relative simplicity in terms of the mechanical transmission components required, electrical vehicles allow for higher flexibility in terms of appearance of the vehicle and its interactive capabilities.

The financial rebound that electric vehicles would cause to the general public is a secondary concern, given the primary problem of establishing of "refueling" stations for electric vehicles.

Recharging an electrical vehicle consumes time and space, making it ineffective already. Recharge can take up to hours for single maximum range utilization. This builds a crowd at the already few stations.

"It is also important to find when the new technology should lead to redefining the existing products in some way." All of the major automotive manufacturers have production EVs, many of which are available for sale or lease to the general public. The status of these vehicle programs changes rapidly, with manufacturers suspending production frequently due to the small existing market demand of such vehicles.

The manufacturers of EVs in the 1990s realized that their significant research and development efforts on ZEV technologies were hindered by unsuitable battery technologies. A number of auto industries started developing hybrid electric vehicles (HEVs) to overcome the battery and range problem of pure electric vehicles. The Japanese auto industries lead this trend with Toyota, Honda, and Nissan already marketing their Prius, Insight, and Tino model hybrids. The hybrid vehicles use an electric motor and an internal combustion engine and, thus, do not solve the pollution problem, although it does mitigate it.

It is perceived by many that the hybrids, with their multiple propulsion units and control complexities, are not economically viable in the long run, although currently a number of commercial, prototype, and experimental hybrid vehicle models are available from almost all of the major automotive industries around the world. Toyota, Honda, and Nissan are marketing the hybrid vehicles well below the production cost, with significant subsidy and incentive from the government.

Motivated by the growing concern about global pollution and the success of electric motor driven transportation in various areas, the interest is ever increasing for road EVs that can deliver the performance of ICEV counterparts. The major impediments for mass acceptance of EVs by the general public are the limited EV range and the lack of EV infrastructure. The solution of the range problem may come from extensive research and development efforts in batteries, fuel cells, and other alternative energy storage devices.

## 2. HYBRID TWO WHEELERS

The automotive industry has seen the foundation and evolution of hybrids for over ten years now. But, the major progress that has happened from the automotive scenario is in the four-wheeler base. Two wheelers are yet to make a significant progress on the road of developing hybrids. The condition with the two-wheeler phase is that the research is still on-going, rendering the mass production of two-wheeler hybrids as of yet, unavailable.

Mopeds, electric bicycles, and even electric kick scooters are a simple form of a hybrid, powered by an internal combustion engine or electric motor and the rider's muscles. Early prototype motorcycles in the late 19th century used the same principle.

The difference between the two-wheeler and four-wheeler phase is the percentage increase in cost of production and the changes required to develop the hybrid system itself. The change in the cost of hybridization is higher in the case of four wheelers but the amount becomes considerably low when compared to the entire price of the vehicle itself. The same does not apply to two wheelers. The change in cost for hybridization causes a larger change of marginal cost in the production of the vehicle. As such, hybrid motorcycles are infamous as of now.

The second major factor why motorcycles have not seen a proper hybridization scenario is the placement of the components required to convert the combustion to hybrid. Hybridization, basically becomes addition of electrical components to the already existing combustion power train. Quite simply, it requires more area. The current proposed designs result in a change of dimensions of the entire vehicle, making them wider and increasing their volume.

Motors are the "work horses" of Hybrid Electric Vehicle drive systems. The electric traction motor drives the wheels of the vehicle. Unlike a traditional vehicle, where the engine must "ramp up" before full torque can be provided, an electric motor provides full torque at low speeds. The motor also has low noise and high efficiency. Other characteristics include excellent "off the line" acceleration, good drive control, good fault tolerance and flexibility in relation to voltage fluctuations.

A conventional two-wheeler is propelled by an internal combustion engine. The IC engine consumes more fuel and produces pollution. Several manufacturers are planning to move to electric vehicles. But there are quite a few hurdles to

bring in the hybrid technology to two-wheeler segment.

## 3. SAMPLING METHODS

This study is based on convenience sampling method. Convenient sampling method was employed since all random selection of employees was restricted in the University. The sample to whom the questionnaire was administered participated in research out of their free will and without any involvement of the management. There are about 30000 employees working in this unit and around 200 volunteers as per their availability and convenience were canvassed to study the level of hybrid implementation satisfaction. Sample selection and size should be representable of the target population- 200 people are used as a sample to represent the general public in terms of usage of vehicles. The study employs a large sample to create minimalistic deviations from the actual population

## 4. PERCENTAGE ANALYSIS

Percentage refers to a special kind of ratio. Percentages are used in making comparison between two or more series of data. Percentage is used to describe relative terms the distribution of two or more series of data.

Percentage of the respondents = (Number of respondents ÷ Total number of respondents) × 100

## 5. DATA ANALYSIS AND INTERPRETATION

### 5.1 Respondent's Gender

| Attribute | Count | Percentage |
|---|---|---|
| Male | 169 | 88.5% |
| Female | 22 | 11.5% |

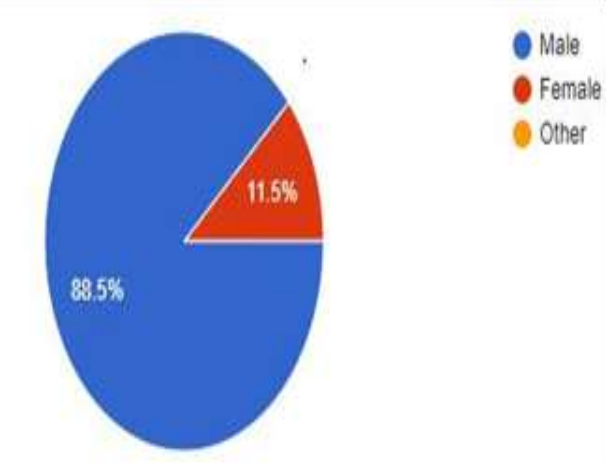


**Chart -1**: Gender Pie Chart

Interpretation: The above table indicates that majority of the sample population comprises of males and the minority is females. The results do not affect the purpose of the project in a very significant manner as the main objective is independent of the basis of gender. The large male majority can be attributed to the streams to which the questionnaire was mainly spread into, namely Mechanical and Civil.
The treams by themselves consist of a male majority and a female minority, which explains the results obtained when the gender of the respondents was evaluated. The following result aids the project in a way due to the possession of vehicles mainly by the male majority. This results in better evaluation of the entire project.

### 5.2 Respondent's Age

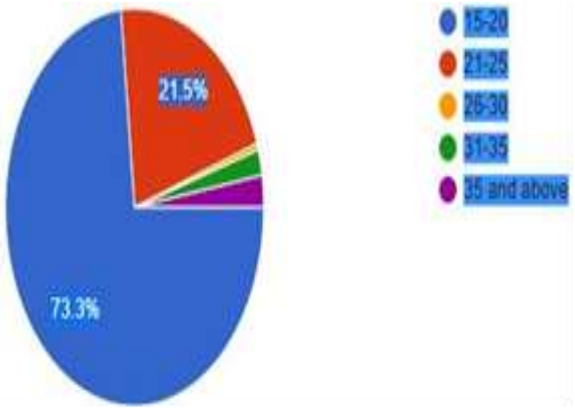


**Table -1:** Respondent's Age

| Attribute | Count | Percentage |
|---|---|---|
| Between 15-20 | 139 | 73.3% |
| Between 21-25 | 41 | 21.5% |
| Between 26-30 | 2 | 0.8% |
| Between 31-35 | 4 | 2.1% |
| 35 and Above | 5 | 2.3% |

Interpretation: The above table indicates that majority of the respondents are between the ages of 15 to 25. As majority of the respondents are from within the university, the result is justified attributing to their requirements of savings on fuel cost and performance requirements.

### 5.3 Respondent's Profession

| Profession | Count | Percentage |
|---|---|---|
| Student | 173 | 90.6% |
| Employed | 6 | 3.4% |
| Self employed | 6 | 3.4% |
| Retired | 2 | 0.8% |
| Homemaker | 4 | 1.8% |

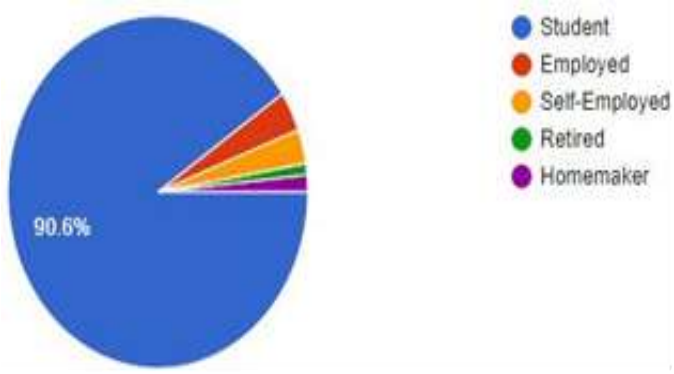


**Chart -3**: Profession Pie Chart

Interpretation: The above table indicates that over 9 out of 10 people who have responded are students, attributing to their presence in the university. The rest comprise of various faculties and authorities around the campus.

**5.4 Distance of Travel**

| Attribute | Count | Percentage |
|---|---|---|
| Less than 5km | 91 | 47.6% |
| 5km to 20km | 56 | 29.3% |
| 20km to 50km | 35 | 18.3% |
| Over 50km | 9 | 4.8% |

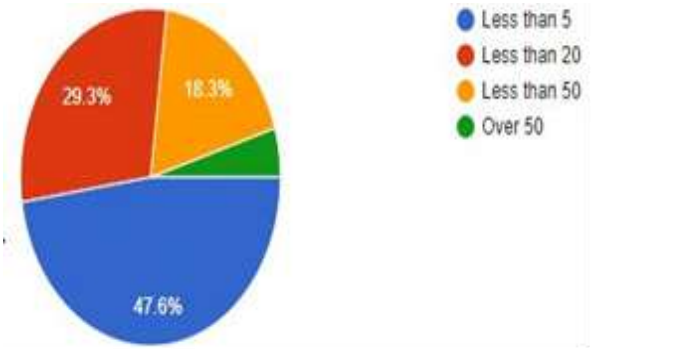


**Chart -4**: Distance Travelled Pie Chart

Interpretation: The above table shows the travel distances each day that a particular person covers. The range is widespread and hence provides a variation in the effect of hybrids that may be caused.

**5.7 Probability of Purchase**

| Attribute | Count | Percentage |
|---|---|---|
| Yes | 98 | 51.4% |
| No | 56 | 29.5% |
| Maybe | 37 | 19.1% |

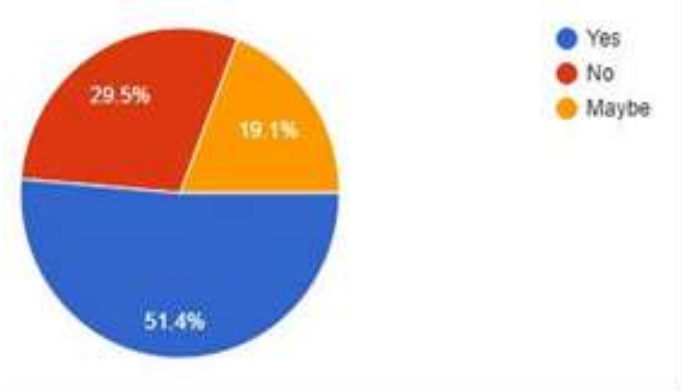


**Chart -5**: Probability of Purchase Vehicles Pie Chart

Interpretation: The above table indicates that people do have a high tendency towards purchasing a hybrid vehicle considering the many benefits outlined by the purchase of a hybrid vehicle over the conventional vehicle.

**5.8 Hybrids for replacement over Electric Vehicles**

| Attribute | Count | Percentage |
|---|---|---|
| Yes | 113 | 59.2% |
| No | 33 | 17.3% |
| Maybe | 45 | 23.6% |

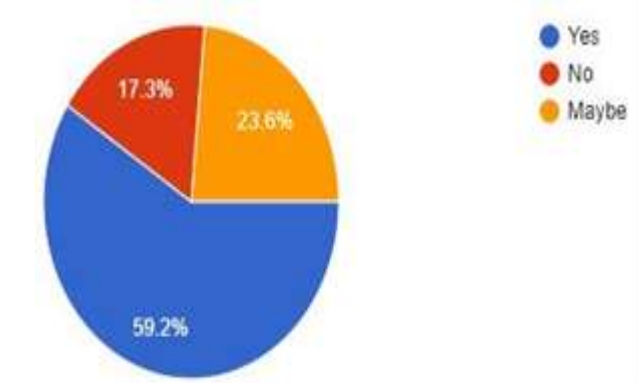


**Chart -6**: Hybrids for replacement over Electric Vehicles Pie Char

Interpretation: The above table indicates that the major population would prefer a hybrid over an electric vehicle due to various reasons such as cost, complexity, lack of refueling stations. The data clearly puts hybrids at the forefront.

## 6. TECHNICAL INTEGRATION

### 6.1 Motor Specification

RIM WITH HUB MOTOR ASSY. Of Hero Electric Optima Plus
Hub Motor with Drum Brake
Motor (with Alloy Rim): 16'' x 3'' with WPC
Rim Specification: 16'' x 3''

| | |
|---|---|
| Brake: | Drum Brakes |
| Electric: | 250 Watt BLDC Hub Motor |
| Operating voltage: | 48 Volt 24AH |

**6.2 Specifications:**

| | |
|---|---|
| Voltage: | 48V |
| Wattage: | 48V 250-3000W |
| Throttle: | 1-4V |
| Short voltage protect: | 31.5±0.5V/72±0.5V |
| Dimension: | 105 x 65 x 32mm/4.13 x 2.56 x 1.26″ |
| Casing material: | Aluminium |

*Operation:*

1. *Blue/Black* – cruise/ground
2. *White wire* – self-learning (plug two white wire together)
3. *White/Black* – Brake (low)/brake (low)
4. *Purple* – Brake (high)
5. *Red/Black/Green* – throttle positive/throttle negative/ throttle signal
6. *Red/Black/Thin Yellow/Thin Blue/Thin Green* – +5V/ Earthing/ Motor Hall lines
7. *Thin Blue* – instrument
8. *Red/Blue/Black* – +5V/Signal/Earthing (Pedal Assistant)
9. *Thick Blue/thick Yellow/Thick Green* – Motor phase lines
10. *Thick Red/Thick Black/Thin red* – power positive/power negative/power lock

**Fig -1**: Hub motor with drum brake

**Fig -2**: Motor controller for donor vehicle

**6.3 Proposed changes in donor vehicle**

There are a few changes we would like to propose in main donor vehicle,

*Replacement of rear tire with hub motor* – The rear tire will be replaced by a hub motor for better performance in terms of less weight and high running life throughout. Replacement of tire with a hub motor requires a small change in the donor vehicle, along with an additional component to provide proper alignment to the hub motor.

*Utilizing the boot space* – The boot space in the donor vehicle can be used to place the controller and the battery which will be mounted on a nearby member

*Addition of charging port under the seat* – A charging port is required to charge the batteries. As such, a charger will be placed under the seating area of the vehicle to allow for recharge of the batteries

*Mounts* – Mounting will be provided to support the motor controller and the battery. The boot space will be made use of to place the controller and the battery and its corresponding mounts

**Fig -3**: Isometric view of the proposed assembly

**Fig -4**: Front view of modified assembly

**6.4 Calculations**

$C_{rr}$= **0.015**
$m$ = **180 kg** (including driver)
$C_{rr}mg$ =0.015 x 180 x 9.81 =**26.487 N**
$E_{battery} = (f_{battery} * r_{elect})/0.8$

where $E_{battery}$ is the maximum battery energy storage in Wh, $f_{battery}$ is the electric energy consumption of all electric operations in Wh/km and $r_{elect}$ is the all-electric range in km.

$r_{elect}$ = **10km**
$E_{battery}$= 48V * 24Ah
= 1152 Ah
= **1.152 kWh**
1.152 kWh= ($f_{battery}$* 10km)/0.8

Hence, $f_{battery}$= 0.0921kWh/km = **92.1 Wh/km**
$E_{battery}$= **1152 Wh**
ScLi-ion = **1.30 Wh/kg**
The battery mass can be calculated as
mb = $E_{battery}$/Sc
where mb is the battery mass in kg and Sc is the specific energy of the battery in Wh/kg.

mb = 1152/130 = **8.86 kg**

The key advantage of plug-in hybrid electric two-wheeler is the all-electric range (AER). The all electric range emphasizes all electric vehicle operation over a desired distance in which the battery discharges to a minimum threshold. Battery will only be discharged to 80% degree-of discharge (DOD), which is the highest DOD permitted in the interest of good battery cycle life (Wong et al 2006). The maximum battery energy storage is the core part of the plug-in hybrid electric two-wheeler system design and it is calculated as such.

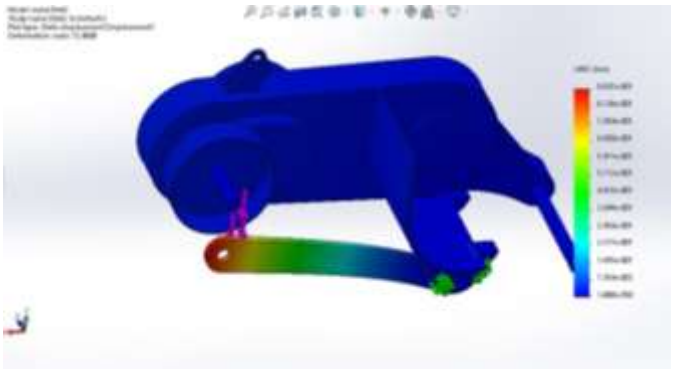

**Fig -5**: FEA analysis with maximum deformation 0.067mm

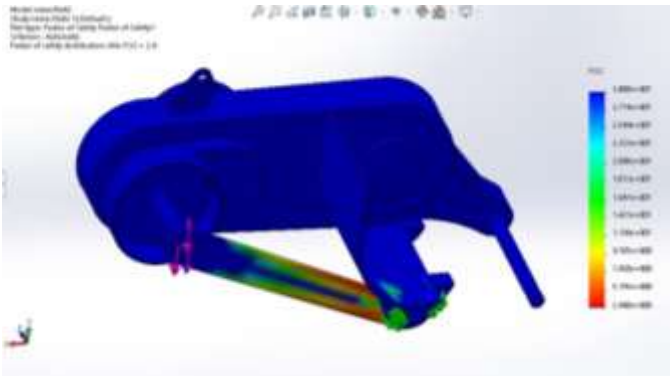

**Fig -6**: FEA analysis with minimum of FOS 2.9

## 7. CONCLUSION

The study shows that the implementation of hybrids can prove to be a huge success given the right marketing strategy and performance delivery. The wholesome positive response from the considered population shows that the hybrids have a huge potential in the current market, especially when the prices of fuel have gone through the roof. The majority prefers having a more efficient means of transport over one that delivers unnecessary power. In a country such as India, hybrids have become a necessity due to extensive population and focus on education. Two wheelers are the main mode of road transportation in major cities and reduction in pollution and cost of travel is a boon for all. The proposed hybrid system has been acknowledged by a major multi-national automotive company based in India. The benefits are available to people of all ages and professions who utilize two-wheeler transport often. The cost of implementation of the hybrid system will reflect in the base price of the vehicle, but in the long term, the savings on the cost of fuel per km will prove to be more beneficial.

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