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Design and Development of Hybrid Vehicle using Four Different Sources of Energy

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ABSTRACT- These days, where there are energy crises and the assets are depleting at a higher rate, there is a necessity for specific innovation that recovers the energy, which gets commonly squandered, and to find new sources of energy. Thus, if there should arise an occurrence of cars one of these valuable innovations are the HYBRID VEHICLES. By the actual name it tends to be surmised that a hybrid vehicle is an extemporization to the conventional gasoline run vehicle joined with the force of an electric engine. In this project, we created a working model of a system that can charge its battery from four different sources. This system can further be replaced with the existing electrical system of hybrid vehicle technology. Hence, improving energy efficiency and leading to even lower emissions than the conventional hybrid vehicle.

Keywords: HV (Hybrid Vehicles), ICE (Internal Combustion Engine), Solar Energy, Sound Energy, Wind Energy, Regenerative Braking.

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1. INTRODUCTION

Currently, the majority of our automobiles run on fossil fuels. However, in less than 100 years, we will run out of fossil fuels totally. The engine vehicle outflows are the mix of different toxins which can possibly bring about unfavorable wellbeing impacts. As per various examinations, engine vehicle outflows are a combination of different pollutants that can possibly cause negative wellbeing impacts (Sharda Kosankar & Chetana Khandar, 2014)[1].Thus, developing and implementing effective vehicle emission reduction measures is advised. Consumers all around the world are bearing the brunt of rising fuel costs and global warming's repercussions. Thus, electricity independence is quickly becoming a necessity for the future. Hence, the hybrid automobile is a promising substitute for the conventional automobiles. These hybrid vehicles have a variety of advantages. A hybrid car is one that uses both an electric motor and a gasoline engine to propel it. The hybrid automobile saves money on gas since it is more fuel efficient and has a lower rate of consumption than non-hybrid vehicles. Due to its unique properties, hybrid cars offer a lot of benefits. The hybrid vehicle is made of lighter materials than a conventional vehicle. This reduces the amount of energy used to propel the hybrid car, which saves energy.

1.1 Current Situation of Hybrid Vehicles in India

In India, the vehicle population is increasing at the pace of more than 5% per annum and today the vehicle population is roughly 40 million (Sharda Kosankar & Chetana Khandar, 2014) [1].In India, the transportation market produces an expected 261 tons of CO2, with street transport representing 94.5 per cent. The transportation sector consumes roughly 17% of total energy and is responsible for 60% of greenhouse gas emissions from diverse activities. Therefore, limiting dependence on petroleum product vehicles and shifting to hybrid and electric vehicles is necessary. Accordingly, to decrease vehicular outflows and air contamination levels inside the country FAME India was introduced in 2015.

1.1.1 FAME India 1

The FAME India Scheme which stands for Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India is an Indian's government initiative to reduce the use of diesel and petrol-powered vehicles in the country. The initiative is a key component of the government's National Electric Mobility Mission Plan (NEMMP).The objective of the plan was to facilitate the sale of 6-7 Million Electrical and Hybrid vehicles by the year 2020. (*FAME India Scheme*, 2019) [2].

1.1.2 FAME India 2

Originally, this program started from January 1, 2019 through March 31, 2022.The FAME II scheme has been continued by the Indian government for additional two years. This scheme will now be in effect until March 31, 2024. (Madhuri, 2021) [3]. This phase intends to assist roughly 7000 e-buses, 5 lakh e-3 wheelers, 55000 e-4 wheeler passenger cars, and 10 lakh e-2 wheelers through subsidies. According to reports, the two-wheeler market will primarily target private automobiles owned by residents of big cities. The government of India will build a large number of charging stations as part of this initiative to encourage the usage of electric vehicles and the use of energy rather than diesel or petrol.

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1.2 Current Situation of Hybrid Vehicles in the World

1.2.1 Recent Developments in Japan

Toyota has long asserted that battery-controlled vehicles are certifiably not a decent answer for environment and contamination issues since the batteries are excessively costly and take too long to even think about charging. Hybrid gas-electric vehicles, which the business spearheaded, were viewed as the best alternative.

Jun Nagata, a Toyota executive, said during a press conference that the expense of batteries for electric vehicles (EVs) and the accessibility of frameworks all over the planet could never have progressed fundamentally by 2030. Purchasers will find hybrids and plug-in hybrids more viable to purchase, as per the association. By 2030, Toyota will have financed 1.5 trillion yen (US$13.6 billion) in batteries for electric and hybrid vehicles, recovering its position as the world's best-selling car manufacturer. Essentially, the carmaker is reaffirming its obligation to hybrid vehicles, an innovation it spearheaded. A conventional Toyota hybrid is gasoline controlled with an electric motor to further improve efficiency. The automaker's greatest business markets, like China and the United States, are probably going to see ventures. In the interim, the organization intends to grow production in Japan through a joint partnership with Panasonic. Toyota has claimed that by 2030, it intends to sell 8 million electric and hybrid cars. 2 million electric vehicles and energy unit vehicles are included for this aim. Electric or fuel cell vehicles will address 40% of deals in Europe, 15% in North America, and 10% in Japan, as demonstrated by geography.(Dashveenjit Kaur, n.d.) [4]

1.2.2 Recent Developments in China

On account of its production limit and customer demand, China is a key player in the worldwide hybrid vehicle market. Following the pandemic, China's economy started to get steam, and interest for hybrid and plug-in hybrid electric vehicles started to rise. In China, for instance, more than Two Lakh Twenty Thousand new plug-in hybrid electric vehicles (PHEV) were bought by customers in 2020. Players in the business are supposed to be supported by such circumstances. Because of the gigantic vehicle deals in Asia Pacific, China possesses a critical piece of the business. Foreign firms' interests in rising nations, as well as expanded consciousness of the benefits of hybrid vehicles, are projected to have a good influence on this provincial market. Toyota and Honda at present rule the hybrid vehicle class in China, with models including the Honda Accord Hybrid and Toyota Corolla Hybrid. Corolla Hybrid sold more than 30,000 units in China in the initial 3/4 of 2019, addressing a generally 20% increase in all out-hybrid transports during the period. The Chinese government actually broadcasted measures to help the new energy vehicle (NEV) industry, which was hard hit by the COVID-19 episode, by loosening up sponsorships that were set to pass by 2020 and showing new financial backers that could keep up with the country's half and half electric vehicle market for a long haul. The market for hybrid and electric vehicles created at the fastest rate in China. An overflow of 30 Chinese metropolitan organizations have set up plans to accomplish 100% electric public transportation by 2020 (*Hybrid Vehicle Market Share, Growth | 2022 - 27 | Industry Analysis*, n.d.) [5].

1.2.3 Recent Developments in USA

Legislatures in the United States and Europe are concentrating on diminishing discharge norms to lessen ozone depleting substance emissions, as well as further improving car fuel economy. The Corporate Average Fuel Economy (CAFE) criteria for automobiles, for example, were established by the US Department of Transportation. In the Middle East region, electric and hybrid types of transportation are getting some forward momentum, especially in Israel, Jordan, Oman, Saudi Arabia, and the United Arab Emirates. Dubai's Roads and Transport Authority, for instance, recently reported aggressive aspirations to change half of the emirate's cabs completely to crossover vehicles by 2021. (*Hybrid Vehicle Market Share, Growth | 2022 - 27 | Industry Analysis*, n.d.) [5]. As per information from analytics firm Wards Intelligence, hybrid vehicle deals in the United States expanded by 76% to 801,550 vehicles last year, representing 5% of all light vehicle deals in the country.

Toyota Motor Corp (7203.T) set another achievement for hybrid car deals in the USA, permitting the Japanese carmaker to outperform General Motors Co (GM. N) as the nation's top seller. Toyota expanded deals of hybrid, plug-in hybrids, and fuel cells by 73% to 583,697, with hybrids representing most of the increase. Since the Bolt EVs were owed to battery fire perils, GM sold less than 25,000 electric vehicles. (*U.S. Hybrid Electric Car Sales Hit Record Highs | Reuters*, n.d.) [6]

2. LITERATURE REVIEW

2.1 Review of Literature

Hybrid Automobiles have been a part of automobile history for the past hundred years. The Lohner-Porsche Mixte Hybrid, designed and produced by **Dr. Ferdinand Porsche (1898)**, was the **first petrol-electric hybrid**. The car's internal combustion engine spun a generator that powered four 2.5-3.5 horsepower electric motors in the wheel hubs. The car had a battery-only range of 40 miles and a top speed of 30 mph. (*Lohner–Porsche - Wikipedia*, n.d.)**[7]**. The Mixte was generally welcomed, and more than 300 were created. The interest for cross breeds started to disappear, in any case, when Henry Ford began the principal car mechanical production system in 1904. Ford's capacity to create fuel-controlled vehicles and deal them at low costs emphatically contracted the hybrid vehicle market. During the 1960s, the United States Congress presented regulation that supported more prominent utilization of electric vehicles trying to lessen air contamination. With propels in innovation, the GM 512 was acquainted with market. It ran totally on electric enhancer to 10 mph. From 10-13 mph, it ran on a blend of batteries and its two-chamber petroleum motor. Above 13mph the GM 512 ran on petroleum, with a maximum velocity of 40mph.(SAM, 2020) **[8]** 1999 saw the two-entryway Honda Insight sent off in the United States and Japan. The principal hybrid vehicle to hit the mass market in the United States, the Insight was equipped for a consolidated pattern of 78 mpg and won various honours for its advancement.

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C.C Chan (2002) expressed in his research that in early years the significant expense and short scope of electric vehicles have hampered its commercialization. Hybrid electric vehicles and energy unit electric vehicles will emerge therefore. The major trouble with Hybrid Electric Vehicles, be that as it may, is the manner by which to advance different energy sources to accomplish the best presentation at the least expense.(Chan, 2002) [9] **Martin Weiss, Andreas Zerfass, Eckard Helmers (2018)** explored that the expenses for alleviating CO2 and air contamination outflows by electric and plug-in hybrid vehicles disperse over wide ranges. Electric vehicles can moderate CO2 and poison emanations, in any event, while thinking about the roundabout discharges from power age and battery creation. The CO_2 alleviation costs will probably keep on diminishing in the future because of innovative learning and a developing commitment of renewables to the power blend.(Weiss et al., 2019) [10] **Parag Jose, C. Meikandasivam, S. (2017)** investigated that The eventual fate of hybrid electric vehicles is tremendous. There is a ton of room for better and more effective vehicles to be created. Two of the most explored regions today managing utilization of sustainable power frameworks in hybrid electric vehicles are sunlight based controlled and wind-fuelled electric vehicles. They said that Research on growing better, more productive, stronger, and easier to understand sunlight powered chargers could upset the hybrid vehicle industry. The principal disadvantage of mounting up of the breeze turbine on the vehicle is that the drag force following up on the vehicle lessens the proficiency definitely in this manner making the breeze turbine an obligation. To conquer this, the plan could be acted in such a way that the breeze turbine is disguised; subsequently empowering the breeze to be smoothed out to the turbine without summoning quite a bit of drag force. The hybrid electric vehicles would in future be utilized more and empower a support advancement of the world (Parag Jose & Meikandasivam, 2017). [11]

2.2 Research Gap

Most of the hybrid cars in the world contain gasoline engines for sure and other alternatives most of the time electric one. By creating hybrid vehicle first of all will reduce the amount of emissions significantly. Although it may cost higher but can be used in upcoming years with new innovations by the engineers as fuel prices are increasing day by day and it is leading to inflation in most of the developing countries like India which imports most of its fuel requirements from other countries. We have tried what we could and we'll advise the future researchers to use the study to innovate and work on these prototypes and conduct various researches and to come up with something more useful and innovative by using these findings and can also improve this too.

2.3 Research Objectives

1. To find an alternative in which gasoline engines can be ignored by using renewable sources of energy such as solar, wind, regenerative braking, and sound.
2. To analyze various research papers and articles to write these findings.
3. To explain about each resource and their mechanism.
4. To develop a prototype model of the hybrid vehicle using all these resources.
5. To calculate overall cost of gasoline and hybrid variants and discuss the cost analysis.
6. To examine a case study on world's most famous hybrid vehicle i.e. Toyota Prius Series and why it had outperformed its competitors in the market.

3. TECHNOLOGY AND PROCESS

3.1 Electricity from Regenerative Braking

A regenerative shock absorber transforms parasitic discontinuous straight movement and vibration into valuable energy, like power. Shock absorbers of the past just disseminate this energy as thermal energy. At the point when used in an electric vehicle or hybrid electric vehicle, the shock absorber's power can be diverted to the vehicle's engine, broadening battery duration. (*Regenerative Shock Absorber - Wikipedia*, n.d.) [12]

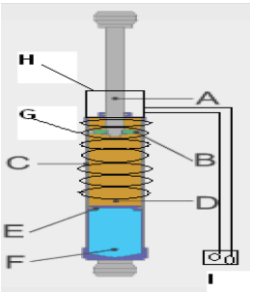

Figure 1: Electricity Generating from the Regenerative Shock Absorber

G - SPRING ACTION TO PROVIDE MOTION
H - SOLENOID COIL
A - PERMANENT MAGNETS TO PROVIDE INDUCED EMF
I - ELECTRICAL ENERGY OUT
E - SHOCKER ROD AREA
C- RUBBER SPRING/COVER TO PROTECT DUST.
B - ROD TO CONNECT WHEEL
F - ELECTRICITY OUT FOR BATTERY CHARGING
D - RACK AND PINION GEAR ASSEMBLY

A DC support converter is utilized to help the produced emf to a suitable level for charging the battery, or a SC connected in series and corresponding with the batteries to set up charging voltage (Verma et al., 2021)[13].

At the point when the liquid goes through the turbine (when the shock responds to obstacles) the turbine turns a little generator and more power is made. Suspension is a lost cause on a vehicle and albeit this framework won't change that reality, it should effectively utilize that squandered energy and make power. Thus, this power is then fit for providing your vehicle with the power it necessities and this requires less use from an alternator. By overburdening the motor it will run all the more productively and give you more miles per gallon.

It can possibly further develop energy change proficiency and lift driving reach, which is one of the significant advances for

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EV center intensity. As indicated by studies, regenerative slowing down can increase driving reach by up to 8%-25% and up to half of complete brake energy can be recovered in the metropolitan driving cycle.(Verma et al., 2021) [13]

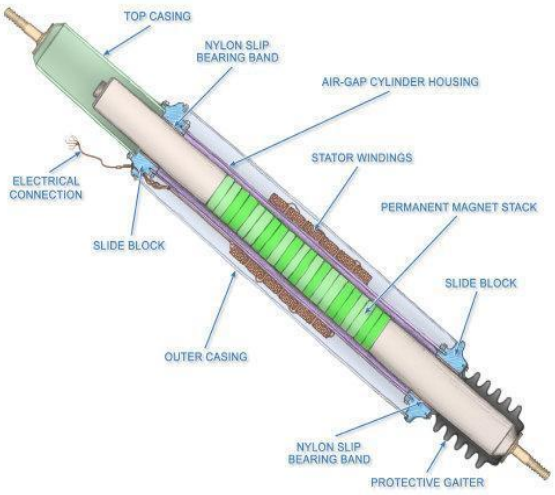

Figure 2: Regenerative Shock Absorber

3.2 Solar Energy

The most valuable approach to saddling sun-powered energy is by straightforwardly changing it over it into power through sun-oriented photograph voltaic cells. The cause for photovoltaic conversion is the photovoltaic impact, or the conversion of solar energy from the sun into electrical energy. Solar cells, which are made up of semiconductor materials with an artificially delivered continuous electric field, are used to complete this process (through a pn junction). (Bayod-Rújula, 2019)[14] The photograph voltaic impact can be depicted effectively for p-n intersection in a semiconductor.

A PN intersection is the contact surface between a p-type and an n-type semiconductor.

Right, when p-type and n-type semiconductors are invigorated, carriers, for instance, openings and free electrons are attracted and bound, and they vanish at the boundary. It's known as a depletion layer since there are no carriers around here, and it's in a comparative state as an insulator.

When the "+" pole is connected with the p-type area, the "- " post is connected with the n-type region, and a voltage is applied, electrons move progressively from the n-type to the p-type region. The electrons will initially disappear when they combine with holes, yet any overabundant electrons will venture out to the "+" post, causing current to flow. (*What Is a Pn Junction? | Toshiba Electronic Devices & Storage Corporation | Asia-English*, n.d.)[15]

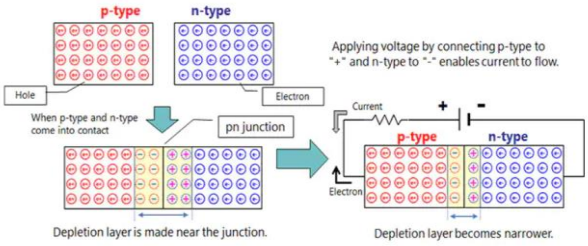

Figure 3: PN Junction Diode

3.3 Sound Energy

Sound is a mechanical wave that may travel through any medium. Sound energy can be transformed to electrical energy or vice versa. When a sound wave travels through a medium, the material within it is displaced and oscillates in time with the sound wave. (Shalabh Bhatnagar, 2012)[16]. Sound energy can be easily transformed to heat energy, which can then be turned to electricity, but this method is inefficient due to the high rate of change, but another method uses a piezo-electric material to convert sound energy totally to control. Crystals that transfer mechanical strain to electric energy are known as piezoelectric materials. As a result, we can see that sound is a type of mechanical energy that can be converted to electric energy using the third rule of thermodynamics. Piezoelectric effect occurs when a piezoelectric substance is compressed. Between the two metal plates is a piezoceramic substance, which is a non-conductive piezoelectric ceramic or crystal. (*What Is the Piezoelectric Effect? | Electronic Design*, n.d.) [17] The material must be compressed or squeezed in order to induce piezoelectricity. When mechanical stress is applied to a piezoelectric ceramic material, electricity is generated. The inverse piezoelectric effect describes how the piezoelectric effect can be reversed. When an electrical voltage is applied to a piezoelectric crystal, it shrinks or expands. Electrical energy is switched over completely to mechanical energy through the converse piezoelectric impact.

3.4 Wind Energy

Wind turbines work by spinning propeller-like blades around a rotor to convert wind energy into electricity. Three elements determine the amount of energy a turbine can extract from the wind: wind speed, air density, and swept area.(*Wind Energy | Open Energy Information*, n.d.) [18].A mechanical connection point, consisting of a step-up gear and a sensible coupling, transports energy from an electrical generator. The conclusion of this generator is linked to the battery or framework lattice. The battery is linked to the inverter. The inverter is a device that converts DC voltages to AC voltages completely. The load receives current from the inverter. A step-up gearbox is typically used to adjust the breeze rotor's relatively slow speed to the higher speed of an electric generator. The Equation for Wind Power is:

$$P = \frac{1}{2}\rho A V^3$$

Where, P is Wind Power
ρ is Air Density
A is area swept by the rotating blades

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Because all of the available energy is not extractable, the maximum wind available will be slightly less than the real quantity. As a result, even a small increase in wind speed can significantly affect wind power. The power available is proportional to air density, according to the equation. Because of pressure and temperature changes, it might vary by 10-15% during the year. The power coefficient refers to the ratio of free-flow wind energy that a rotor can extract. Thus,

Power coefficient =Power of Wind rotor/Power available in the wind.

4. DESIGNING THE WORKING MODEL

Hybrid vehicle drivetrains are responsible for the transmissions of power in hybrid vehicles (*Alternative Fuels Data Center: How Do Hybrid Electric Cars Work?*, n.d.) [19]. All of the components that are used to convert stored potential energy is included in the powertrain. Chemical, solar, nuclear, and kinetic energy can all be used for propulsion in powertrains. Hybrid automobiles have a battery that is supported by an internal combustion engine (ICE) that may either recharge the batteries or power the vehicle.

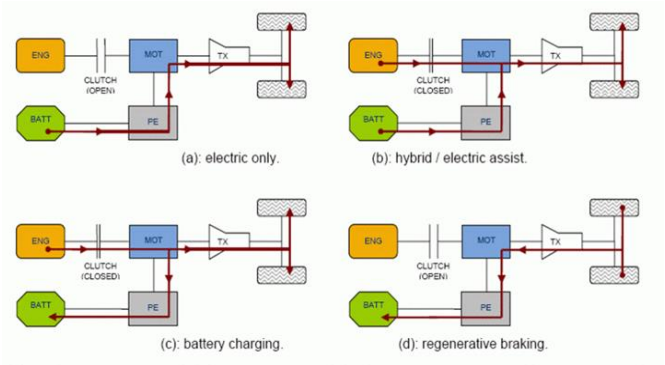

Figure 4: Hybrid Driving System

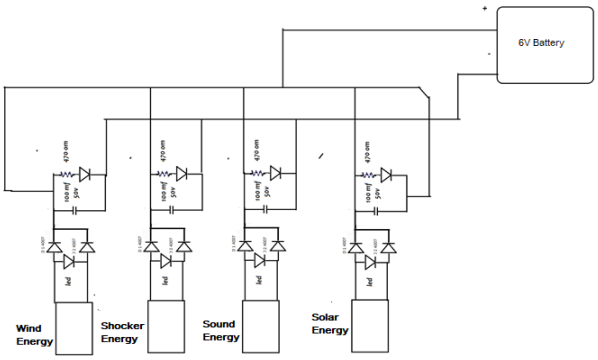

Figure 5: Electric Circuit

4.1 Basic Working Model

The model is set up on a 12x18 inch wooden board base. It is not the model of the entire hybrid vehicle but only the electric power generation circuit. The Solar Panel and the Speaker are fixed on the top of the board. There is a step-up motor and a Fan connected and Regenerative shocker is attached at the base.

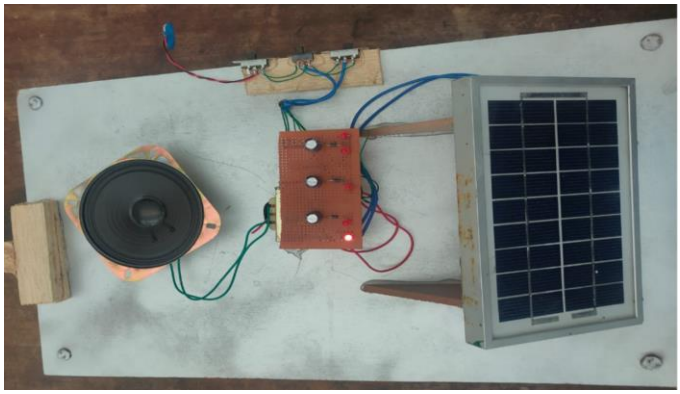

Figure 6: Top View of Model Consisting of Solar Panel and Speaker System

4.2.1 Working Principle

The stepper motor is a brushless motor which has the fan attached to it that is used to generate electricity from wind energy. When the fans move due to the wind, the stepper motor runs at a few hundred rpms. This produces alternating current which then goes through the three phase diode bridge rectifier (present inside the motor) and converts into DC electricity. The voltage produced is up to 6 Volts.

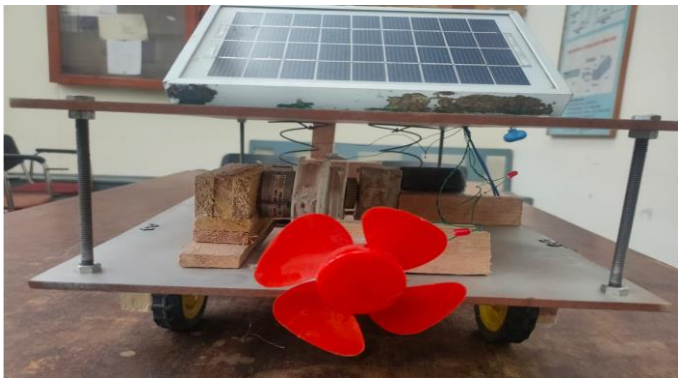

Figure 7: Fan attached with Step-up Motor

When light falls on the solar panel, due to the photovoltaic effect, electricity is produced. The detailed working of a solar panel is discussed earlier.

The speaker system is used to generate electricity from sound. When sound waves strike the diaphragm of the speaker, it vibrates rapidly. There is a piezoelectric diode behind the membrane whose function is to produce electricity from constant pressure acting on it.

Figure 8: Speaker System

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There are two shockers of rack and pinion type attached between the upper and lower boards. They act as regenerative systems that produce current whenever the vehicle is subjected to shocks.

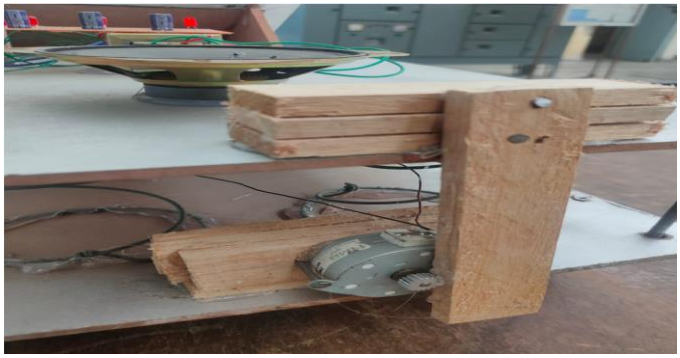

Figure 9: Shocker System

The transformers are step up types that amplify the current produced by the sources up to 512 mA. A 9V battery is also present in case all the other sources are not available.

5. RESULTS AND DISCUSSION

5.1 Results

Here we are comparing two variants of the same company i.e. MG Hector. Comparison of gasoline variant vs. hybrid variant is done based on certain cost factors but not limited to the factors mentioned by us.

Table 1: Comparison of Two Variants of MG Hector [24][25][26](*Cost Comparison: Electric Car vs. Petrol (TCO Analysis)*, n.d.) (*MG Hector Service Cost & Maintenance Charges, Service Schedule*, n.d.) (Carandbike Team, 2022)

Cost Factors	MG hector gasoline variant	MG hector hybrid variant
Purchase price	₹ 13.5 Lakh	₹ 16.38 Lakh
Fuel Economy	14.16 Km/l	15.80 Km/l
Subsidy*	₹ 0	— Upto ₹1.5 lakhs
Lifetime average cost Maintenance	60,000 for 10 years	30,000 for 10 years
Total cost	₹ 14.10 lakhs	₹ 13.53 lakhs

5.2 Case Study on Most Popular Hybrid Vehicle in the World

5.2.1 Toyota Prius Series

The Prius was the primary efficiently manufactured hybrid vehicle when it first went at a bargain in Japan in 1997. It was accessible at each of the four Toyota Japan dealership chains. In the year 2000, it was made accessible worldwide. Toyota sells the Prius in over 90 nations, the biggest of which being Japan and the United States. With over 6,000,000 units sold around the world, the Prius addresses over 70% of all hybrids sold by Toyota Motor Company starting around 1997. The Prius is a strong brand that has started the offer of other Toyota hybrid vehicles (like Aqua, Prius alpha, Estima Hybrid, etc.). (*Toyota Prius - Wikipedia*, n.d.) [20]

Figure 10: Toyota Prius 2015 (XW50)

In the TÜV Report, the Toyota Prius is the main vehicle with elective drive innovation to get ahead of the pack: the Japanese hybrid pioneer topped the rankings for three-year-old vehicles with the lowest rate of major flaws, 2.2 per cent. Subsequently, we can infer that, notwithstanding its monetary and ecological advantages, the Prius has made a huge commitment to the extension and reinforcement of the Toyota brand, making it a truly effective vehicle. As per the authority positioning, the Prius was the most eco-friendly vehicle accessible in the United States in 2019. 95% of all Toyota Prius units sold over the most recent decade are still being used. (Ashley Lobo, 2020) [21]

In addition, as compared to a gasoline-powered automobile, the CO2 emissions of the Prius might be reduced by around 4,500,000 tones. Prius made a significant contribution to the reduction of CO2. The Toyota Prius is a bridging hybrid that is helping Toyota in exploring a significant stretch of electric vehicle vulnerability. Toyota has utilized the Prius to create in-house electric innovation and to develop a client base that is prepared to switch when electric motor advancements supplant burning motor advancements in the standard car industry. (Ashley Lobo, 2020) [21]

5.2.2 Why Prius outperformed all other Hybrid Vehicles?

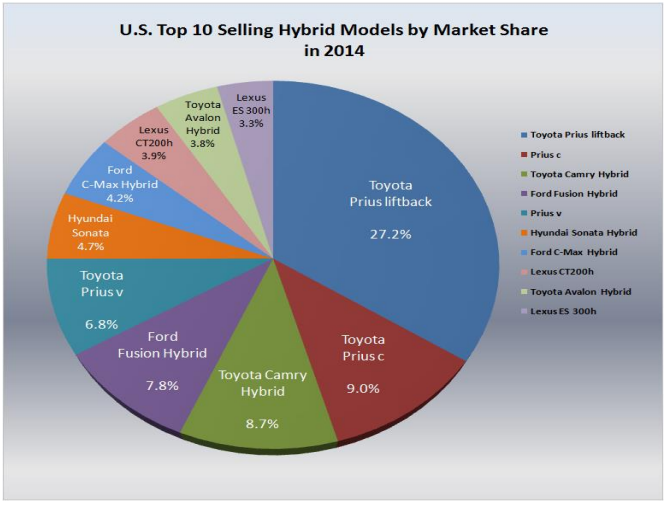

Figure 11: Market Share of Toyota Prius Series in USA (*Hybrid Electric Vehicles in the United States - Wikipedia*, n.d.) [22]

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It's significant that a larger part of buyers surveyed thought the Prius was more affordable than options. As a matter of fact, on the off chance that they didn't buy a Prius, they were more likely to purchase a BMW, Mercedes, or another costly car. The way that the Prius was just accessible as a hybrid was referred to by 71% of respondents as being either significant or critical in their choice. Toyota utilized a penetration pricing strategy technique to acquire market share instead of a skim pricing methodology, which includes setting an excessive cost from the beginning and afterward bringing it down as competitors enter the market. This was effective in acquiring and keeping up with market share. (Ashley Lobo, 2020)[21]

The Prius generates a lot of value for customers:

- Lowers fuel costs
- Decreases time spent filling up the fuel tank
- Creates peer-to-peer buzz because it's instantly recognizable
- Toyota's merited standing for dependability
- Offers public (environmental) benefits without requiring a trade-off.

5.3 Discussion

With rapid increase in fuel prices it is of utmost requirement to find an alternative to gasoline vehicles. Governments are providing tax rebates and launched various schemes to encourage people to take up hybrid and electric vehicles as an alternative.

We have tried to compare the cost of two variants namely gasoline and hybrid of the same company with the same model but having different fuel for transportation. We have calculated estimated overall cost considering few factors which are not limited to these factors only. In the initial phase hybrid car purchasing cost is more than the gasoline cars. Because gasoline engine runs on an estimated 7.44 rupees per km while hybrid variant 6.67 rupees per km we have considered the information provided by CarDekho website.

As in the initial phase it hybrid seems costlier but in the longer run considering various factors like maintenance cost, tax rebates, fuel efficiency and other factors the total cost of hybrid is lesser than the conventional gasoline vehicles.

Also day to day increments in fuel prices should also be considered in the overall cost which is left behind. So at all cost hybrids are better than gasoline fueled vehicles.

The Prius has additionally exhibited that by taking special care of a different arrangement of client needs and utilizing great marking, it is achievable to effectively sell an item across several market groups. Ensure that a green item is included seriously regardless of whether it has any green elements. Then, at that point, with regards to promoting the item, remember that most buys will be made no matter what its natural amicability. Individuals may purchase the item as an extravagance really great for the natural status it infers in the event that you can foster some esteem around it, as long as the item is unmistakable and exceptionally conspicuous.

6. CONCLUSION

Day to day increments in fuel prices led to weaken the economy of developing countries like India which depends on imports from other countries for its fuel requirements. Of the major fuel requirements, a large share of fuel is required to run the vehicles of the nation. Also, external factors like wars and geopolitical situations led to increase the fuel prices along with the high taxes. To compensate this one has to look forward beyond conventional gasoline powered vehicles i.e. Hybrid vehicles which are far better than electric vehicles in the current scenario. Because electric vehicles need developed infrastructures for charging stations which is missing in India. Additionally, India creates its over 70% of power from coal which isn't valuable for electric vehicles as the sole design is to have ecological advantages and decreased fuel costs. Climate insurance and energy preservation have encouraged the advancement of EVs. In any case, the commercialization of EVs was not fruitful. The principal reason was on the grounds that they couldn't fulfil the customers' necessities because of significant expense and short reach.

A demonstrated innovation is as of now accessible out there and with the consistent development in reception rate and expanded accentuation via vehicle producers, the innovation is turning out to be more reasonable and available than any other time. In our research we have accumulated various methods that can be useful in developing a hybrid vehicle using four different sources of energy that are renewable and can be developed in future with further research and development in technology progresses. Also we have calculated the overall cost of same company's gasoline variant vs hybrid variant on some cost factors and the result clearly shows that the hybrid variant is cost effective and cheaper than the gasoline variant in the longer run. With further progress in technology this model can be possible as advancement in technology brings prices down as the time progresses by manufacturing on a large scale. Government can help various startups and established companies to think over newer resources to run HEVs other than petrol.

REFERENCES

[1] Sharda Kosankar, Chetana Khandar, A Review of Vehicular Pollution in Urban India and Its Effects on Human Health - Neliti, Journal of Advanced Laboratory Research in Biology, Vol. 5, No. 3, 1 Jul. 2014, Pp.54-61.(2014)54–61. https://www.neliti.com/publications/279076/a-review-of-vehicular-pollution-in-urban-india-and-its-effects-on-human-health#cite

[2] FAME India Scheme, PIB Delhi. (2019). https://pib.gov.in/PressReleasePage.aspx?PRID=1577880

[3] Madhuri, "Fame India scheme 2022: Apply online, benefits, features & objective," PM Modi Yojana, 30-Mar-2022. [Online]. Available: https://pmmodiyojana.in/fame-india-scheme/

[4] Dashveenjit Kaur, Toyota's billion dollar hybrid dream - Tech Wire Asia, (n.d.).https://techwireasia.com/2021/09/toyotas-billions-of-dollars-worth-hybrid-dream/.

[5] Hybrid Vehicle Market Share, Growth | 2022 - 27 | Industry Analysis, (n.d.).https://www.mordorintelligence.com/industry-reports/hybrid-vehicle-market

[6] U.S. hybrid electric car sales hit record highs | Reuters, (n.d.). https://www.reuters.com/business/autos-transportation/us-hybrid-electric-car-sales-hit-record-highs-2022-01-06/.

[7] "Lohner–Porsche," Wikipedia, 25-Oct-2021. [Online]. Available: https://en.wikipedia.org/wiki/Lohner%E2%80%93Porsche#:~:text=The%20Lohner%E2%80%93Porsche%20Mixed%20Hybrid,%2Dwheel%20hub%2Dmounted%20 motors

[8] S. A. M. MCEACHERN, "1969 GM XP 512 is an early electric city car - GM authority," 1969 GM XP 512 Was an Accurate Depiction of the Future of Mobility, 03-Jan-2020. [Online]. Available: https://gmauthority.com/blog/2020/01/1969-gm-xp-512-was-an-accurate-depiction-of-the-future-of-mobility

[9] C. C. Chan, "The state of the art of electric and hybrid vehicles," in Proceedings of the IEEE, vol. 90, no. 2, pp. 247-275, Feb. 2002, doi: 10.1109/5.989873.

[10] Martin Weiss, Andreas Zerfass, Eckard Helmers,Fully electric and plug-in hybrid cars - An analysis of learning rates, user costs, and costs for mitigating CO2 and air pollutant emissions,Journal of Cleaner Production,Volume 212,2019,Pages 1478-1489,ISSN 0959-6526,https://doi.org/10.1016/j.jclepro.2018.12.019.(https://www.sciencedirect.com/science/article/pii/S0959652618337211)

[11] Parag Jose, C., Meikandasivam, S. (2017). A Review on the Trends and Developments in Hybrid Electric Vehicles. In: Bajpai, R., Chandrasekhar, U. (eds) Innovative Design and Development Practices in Aerospace and Automotive Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-10-1771-1_25

[12] Regenerative shock absorber - Wikipedia, (n.d.). https://en.wikipedia.org/wiki/Regenerative_shock_absorber

[13] S. Verma, S. Mishra, A. Gaur, S. Chowdhury, S. Mohapatra, G. Dwivedi, P. Verma, A comprehensive review on energy storage in hybrid electric vehicle, Journal of Traffic and Transportation Engineering (English Edition). 8 (2021) 621–637. https://doi.org/10.1016/J.JTTE.2021.09.001.

[14] A.A. Bayod-Rújula, Solar photovoltaics (PV), Solar Hydrogen Production: Processes, Systems and Technologies. (2019) 237–295. https://doi.org/10.1016/B978-0-12-814853-2.00008-4.

[15] What is a pn Junction? | Toshiba Electronic Devices & Storage Corporation | Asia-English, (n.d.). https://toshiba.semicon-storage.com/ap-en/semiconductor/knowledge/e-learning/discrete/chap1/chap1-6.html.

[16] (PDF) CONVERTING SOUND ENERGY TO ELECTRIC ENERGY, (n.d.). https://www.researchgate.net/publication/296705888_CONVERTING_SOUND_ENERGY_TO_ELECTRIC_ENERGY.

[17] What is the Piezoelectric Effect? | Electronic Design, (n.d.). https://www.electronicdesign.com/power-management/article/21801833/what-is-the-piezoelectric-effect.

[18] Wind energy | Open Energy Information, (n.d.). https://openei.org/wiki/Wind_energy.

[19] Alternative Fuels Data Center: How Do Hybrid Electric Cars Work?, (n.d.). https://afdc.energy.gov/vehicles/how-do-hybrid-electric-cars-work.

[20] Toyota Prius - Wikipedia, (n.d.). https://en.wikipedia.org/wiki/Toyota_Prius

[21] Case Study of Toyota Prius- The world's most popular Hybrid Electric Vehicle, (n.d.). https://www.linkedin.com/pulse/case-study-toyota-prius-worlds-most-popular-hybrid-electric-lobo/.

[22] Hybrid electric vehicles in the United States - Wikipedia, (n.d.). https://en.wikipedia.org/wiki/Hybrid_electric_vehicles_in_the_United_States#/media/File:U.S_top_selling_HEVs_by_market_share.png.

[23] What are the disadvantages of a hybrid car? | Kia Mauritius, (n.d.). https://www.kia.com/mu/discover-kia/ask/what-are-the-disadvantages-of-a-hybrid-car.html.

[24] "Cost comparison: Electric car vs. petrol (TCO analysis)," The Mobility House. [Online]. Available: https://www.mobilityhouse.com/int_en/knowledge-center/cost-comparison-electric-car-vs-petrol-which-car-costs-more-annually

[25] "MG Hector Service Cost & amp; maintenance charges, service schedule," CarDekho. [Online]. Available: https://www.cardekho.com/mg/hector/service-cost#leadForm.

[26] carandbike Team, "GST & subsidies on electric vehicles in India," carandbike, 28-Feb-2022. [Online]. Available: https://www.carandbike.com/news/gst-subsidies-on-electric-vehicles-in-india2754353#:~:text=The%20government%20has%20provided%20direct,)%20(scooter%20or%20bike)

[27] Sachin B. Shahapure, Vandana A. Kulkarni (Deodhar) and Sanjay M. Shinde (2022), A Technology Review of Energy Storage Systems, Battery Charging Methods and Market Analysis of EV Based on Electric Drives. IJEER 10(1), 23-35. DOI: 10.37391/IJEER.100104.

[28] Femy P. H., Jayakumar J. (2021), A Review on the Feasibility of Deployment of Renewable Energy Sources for Electric Vehicles under Smart Grid Environment. IJEER 9(3), 57-65. DOI: 10.37391/IJEER.0903061.

[29] Vasudeva Naidu Pudi, GVSSN Srirama Sarma, Srinivasa Rao Sura, Prasad Bolla and N Siva Mallikarjuna Rao (2021), Modelling of Electric Vehicle with PID Controller Transfer Function using GA and Model-Reduced Order DRA Algorithm. IJEER 9(4), 135-142. DOI: 10.37391/IJEER.090407.