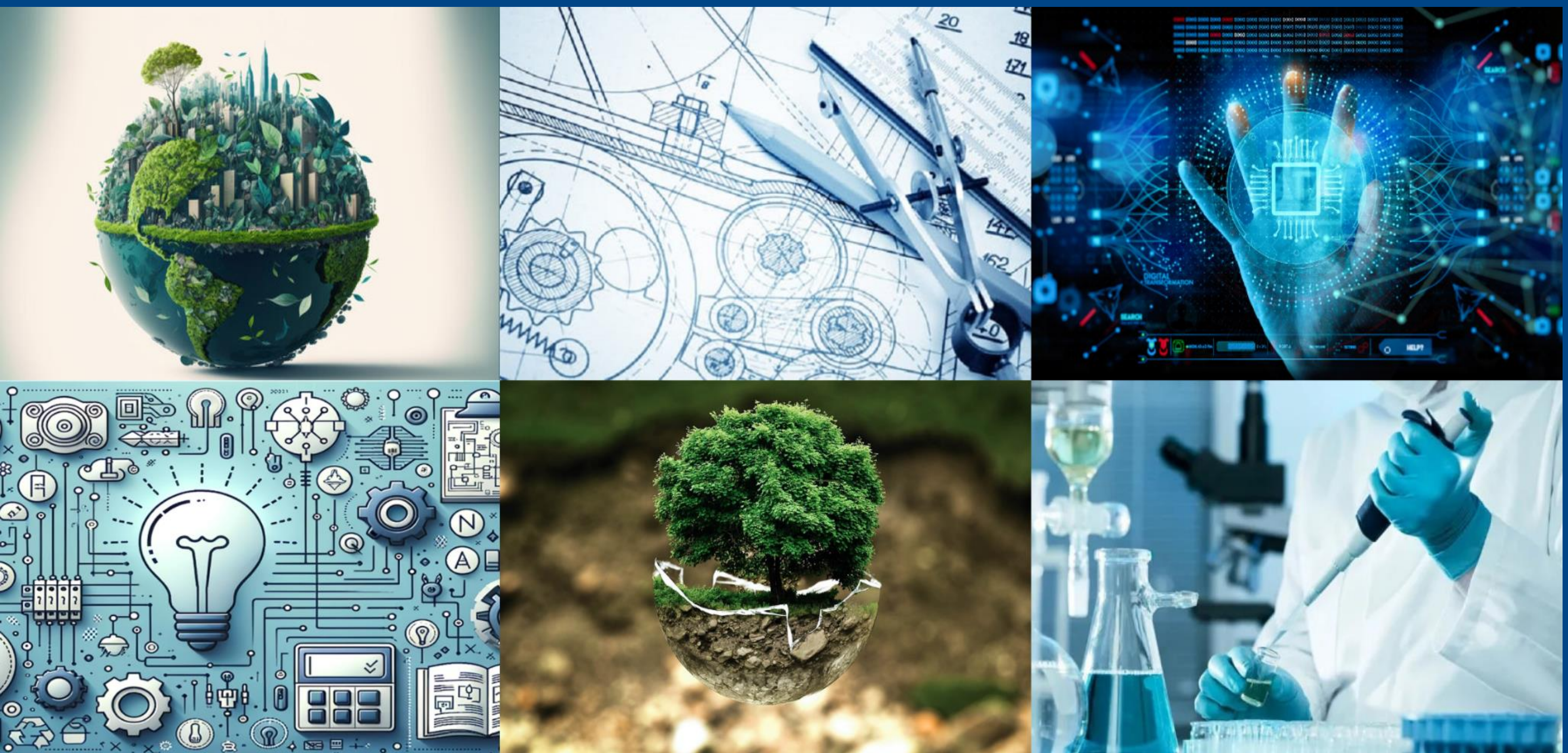
ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206 **Volume 8, Issue 4, April 2025**

www.ijmrset.com ijmrset@gmail.com +91 6381 907 438 +91 63819 07438

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Technological Review in Hybrid Electric Vehicles: Moving Toward Sustainability

Amit Kumar Gupta

Associate Professor, Department of Mechanical Engineering, IET-DAVV, Indore (MP), India

ABSTRACT: Automobile hybridization is also proposed as a vital step to diminish greenhouse gases and associated car emissions. The existing hybrid electric cars are though just a transitionary measure en route to zero-emission road cars. In this paper, an application of the power train in hybrid electric vehicle is mentioned. This vehicle has a facility to provide both fuel-economy as well as performance modes under control strategy. Recently, there has been a lot of interest in the idea of hybrid electric vehicles, which hold enormous potential to achieve greater fuel economy and efficiency. How does a hybrid car function? What is happening under the hood to provide you with 20 or 30 more miles per gallon than the regular automobile? And does it emit fewer pollutants just because it has improved gas mileage? The paper assist us in knowing the technology involved in these hybrid cars. A concise overview of design requirements and selection of key components for hybrid electric vehicles is given**.**

KEYWORDS: Hybrid Vehicles, Energy Saving, Regenerative Braking, Eco Friendly

I. INTRODUCTION

A hybrid electric vehicle (HEV) consists of two forms of energy storage units, electricity and fuel. Electricity implies that a battery (occasionally supported by ultra-caps) is employed to store the energy, and that an electromotor (from now on referred to as motor) will serve as traction motor. fuel implies that there must be a tank, and that an Internal Combustion Engine (ICE, henceforth engine) will produce the mechanical power, or a fuel cell will be employed to extract electrical power from fuel. When the latter is done, traction will be done by the electromotor alone. When the former is done, the car will have both engine and motor.

(a) Depending on the structure of the drive train (how motor and engine are linked together), we can distinguish between parallel, series or combined HEVs.

(b) Depending on the proportion of the electromotor to the traction power, we can differentiate between mild or micro hybrid (start-stop systems), power assist hybrid, full hybrid and plug-in hybrid.

(c) Based on the character of the non-electric source of energy, we have the following possibilities: combustion (ICE), fuel cell, hydraulic or pneumatic, and human. In the initial case, ICE is a spark ignition engines (gasoline) or compression ignition direct injection (diesel) engine. In the initial two cases, the energy conversion device can be powered by gasoline, methanol, compressed natural gas, hydrogen, or other alternative fuels.

In hybrid electric vehicle drive systems, motors can be seen as the "work horses". The electric traction motor drives the wheels of the vehicle. Unlike traditional vehicles where the engine has to "ramp up" a little before it can provide full torque, electric motors provide full torque at low speeds. Additionally, electric motors have low noise and high efficiency. Other distinguishing characteristics are exceptional "off the line" acceleration, good drive control, good fault tolerance and flexibility toward voltage fluctuations. The predominant motor technologies for HEV systems are PMSM (permanent magnet synchronous motor), BLDC (brushless DC motor), SRM (switched reluctance motor) and the more traditional AC induction motor. An advantage of an electro motor (electric motor) is that it can serve as a generator as well. Regeneration of mechanical braking energy is present in all HEV systems. The maximum operational braking torque is less than the maximum traction torque; there is always a mechanical braking system integrated into a automobile. The battery pack in a HEV operates at a higher voltage than the standard SIL automotive 12 Volts battery; in practice this means that the currents are lower and there is no I2R losses. Accessories like power steering and air conditioning are dedicated electric motors and are not burdened to the combustion engine. This opens areas for efficiency gains as well.Literature Review

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

II. BASICS OF HYBRID ELECTRIC VEHICLE

1) HybridizationA hybrid vehicle is defined as a vehicle that has multiple energy sources that can be operated separately or simultaneously to provide propulsion for the vehicle. In the past, various configurations of hybridization from fuel cell, gas turbine, solar, hydraulic, pneumatic, ethanol, electric, and others have been proposed. However, amongst these configurations hybrid electric vehicles have been more popularly accepted by both the technologies and the users of the technologies around the world, as they combine electric motors and internal combustion engines, both technically feasible and well-known from a commercial standpoint [2].

2) Hybrid Electric Vehicle (HEV)Of the various types of hybrid vehicles, hybrid electric vehicles have been the most popular version. HEVs have a propulsion system that uses both an electric motor and an I.C. engine. The power supply for the electric motor is generated from onboard batteries. The HEV configuration describes the use of the I.C. engine together with the electric motor which results in a more optimal use of the engine. The technology of HEVs allows for a vehicle to operate in request starts and stops (which is what driving in city traffic is all about). During idling, the I.C. engine will consume more fuel without producing useful work thereby contributing to higher fuel consumption, lower efficiency, and unnecessary emissions from the exhaust. The HEV configuration has solved this problem by switching power transmission from the I.C. engine to the electric motor.

III. TYPES OF HYBRID POWER TRAINS

The power train of motored vehicles refers to the collections of components that produce power and transfer it to the surface on which a vehicle travels. Hybrid vehicles may be classified as three basic types of power train systems that are briefly noted below[2]. 1. Series hybrid 2. Parallel hybrid 3. Series parallel hybrid.
Series hybrid
A series hybrid system means the combustion engine is not connected to the wheels, as it drives an electric generator (commonly a three-phase alternator and rectifier) instead. The electric motor, using energy from batteries or the generator, is the only means supplying power to the wheels. In low-power situations, the motor directly draws electricity only from the batteries. In high-power demands, the motor draws electricity from both the batteries and generator. Series hybrid configurations have existed for a long time: diesel-electric locomotives, hydraulic earth moving equipment, diesel-electric power grids, loaders.

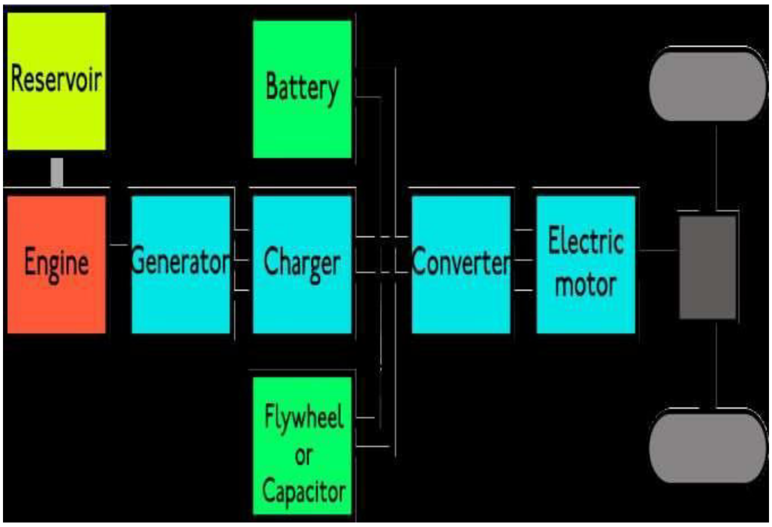


Fig No-:1 Series hybrid Vehicle

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

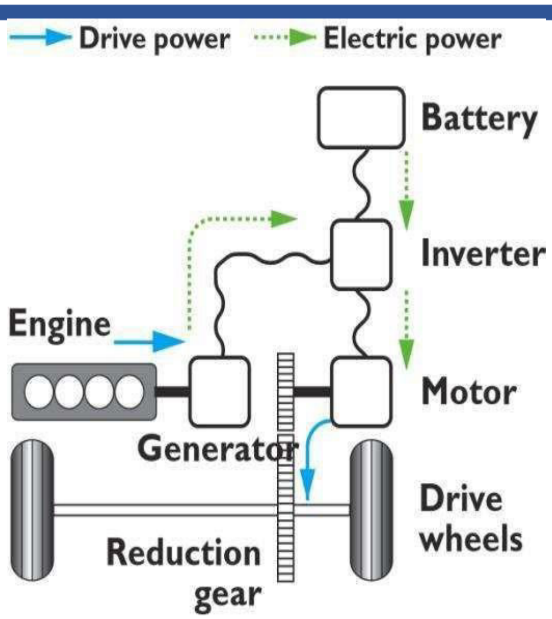


Fig No-:2 Structure of a series hybrid vehicle
(below with flywheel or ultra caps as peak power unit)

Ultra Capacitors (or flywheels: KERS=Kinetic Energy Recuperation System) can assist series hybrids and improve efficiency be reducing losses in the battery. They provide peak power during acceleration and take regenerative power during braking. As a result, the ultra caps are left charged at low speeds and nearly drained at maximum speed. This also reduces deep cycling of the battery, and lowers the stress factor on the battery. There is less need for complex transmissions between motor and wheel because electric motors are efficient over a large speed range. If motors are in the superstructure of the vehicle, they will require flexible couplings. Some vehicle concepts have electric motors on each wheel. The integration of the motors in the wheel adversely impacts ride performance as the unsprung mass increases. Benefits of individual motors on each wheel include easier traction control (no conventional mechanical transmission parts like gearbox, transmission shafts, differential), all-wheel drive, and allow for floors to be lower which is an advantage for buses, for example, and some military vehicles such as 8x8 all-terrain/all-wheel drive vehicles.

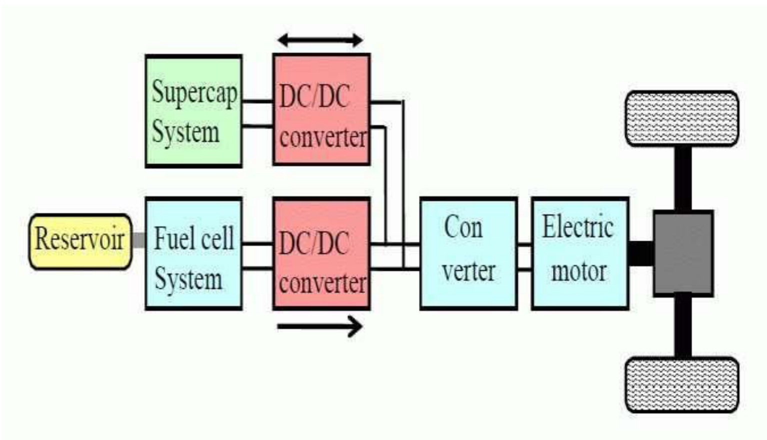


Fig No -: 3 Structures of a fuel cell hybrid electric vehicle

© 2025 IJMRSET | Volume 8, Issue 4, April 2025 |DOI:10.15680/IJMRSET.2025.0804343

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IV. DISADVANTAGES OF SERIES HYBRID VEHICLES

The ICE, the generator and the electric motor are sized to accommodate the full power of the vehicle. This can result in significant total weight, cost and size for the powertrain.

The energy from the combustion engine must flow through both the generator and electric motor, which means the total efficiency during long-distance highway driving is less than with a conventional transmission, due to the multiple energy conversions that occur.

Benefits of series hybrid vehicles:

There is no mechanical connection between the combustion engine and the wheels. The engine-generator combination can be positioned anywhere.

There are no standard passive mechanical transmission elements (gearbox, transmission shaft).

Independent electric wheel motors can be easily used.The combustion engine can work in a very narrow rpm band (its most efficient band), despite changes in vehicle speed. Series hybrid vehicles are, in some respects, the most efficient type of hybrid vehicle during stop-and-go driving in urban environments.

The ICE, the generator, and the electric motor are designed to accommodate the full power output of the vehicle. This can result in a total weight, size, and cost of the powertrain that could be excessive.

Advantages of a series hybrid vehicle:

There is no direct mechanical connection between the conventional combustion engine and the vehicle wheels; the engine-generator group can be placed anywhere. There are no conventional mechanical transmission devices (gearbox, drive shafts), making the installation of independent electric motors at the wheels straightforward.

The ICE can be operated only in a limited engine speed regime (the engine's optimal operating regime) while the car accelerates and decelerates. While there is no definitive measure, series hybrids are likely the most efficient overall with stop-and-go city driving.

A SHEV example is the Renault Kangoo.

Parallel Hybrid -:

Parallel hybrid systems utilize both an internal combustion engine (ICE) and an electric motor in a parallel configuration joined to a mechanical transmission. The majority of designs are done with a sizeable electrical generator and a motor combined as on unit, typically placed between the combustion engine and the transmission replacing both the standard starter motor and the alternator.

The battery can be charged during regenerative breaking, and while cruising (when ICE power is greater than the power required to keep the vehicle moving). It is more mechanically complex than a series hybrid, since the parallel power train is dual driven. In a parallel system both the combustion engine and electric motor are used to propel the car. The given fig shows that the I.C. engine and motor work together.

Typically, the combustion engine works to primarily navigate the vehicle as an ICE, while the electric motor acts as a backup or torque / power booster to support primary propulsion. The benefits of this is that it allows for smaller batteries (less weight), and typically produces more efficient regenerative braking to reduce speed and capture energy. It is also easily incorporated into more existing vehicle models.

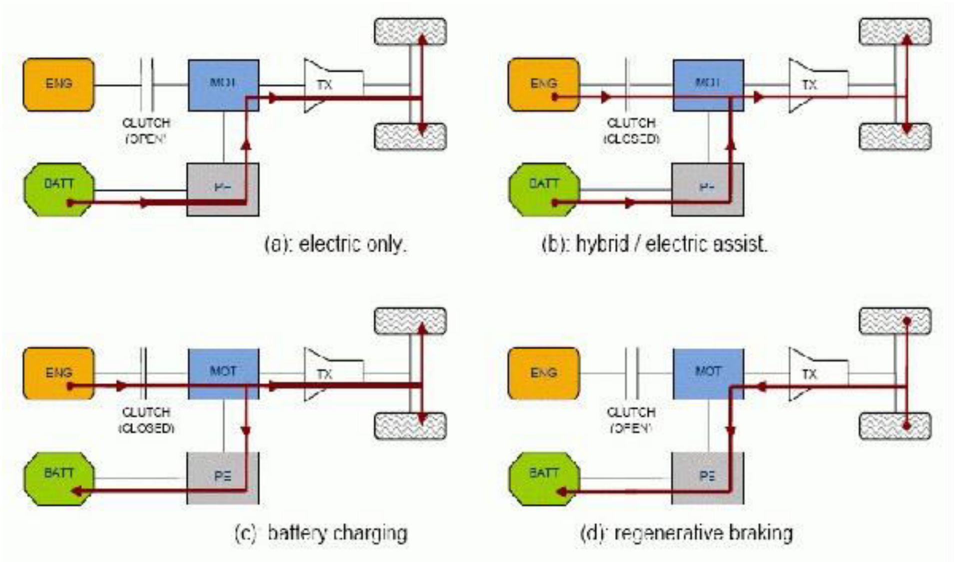


Fig No-: 4 (Some Typical Modes For A Parallel Hybrid Configuration) PE= Power Electronic TX= Transmission

(a) Electric power only: The electric motor uses only the energy from the batteries (which are not recharged by the ICE) at speeds typically up to 40 km/h. This is the typical mode of operation in the city, as well as in reverse, since the speed in reverse is limited.

(b) ICE power only: At speeds greater than 40 km/h, only the heat engine operates. This is the normal operating mode on the road.

(c) ICE electric power: if more power is needed (while accelerating or at high speed), the electric motor turns on to work in conjunction with the heat engine to provide more power.

(d) ICE battery charging: If less power is needed, excess power is used to recharge the batteries. At higher torque than required, the engine will be more efficient.

(e) Regenerative braking: when braking or decelerating, the electric motor uses the kinetic energy of the moving vehicle to operate as a generator. Sometimes, also another generator is available so that the batteries can be charged while the vehicle is not driven and the ICE operates disconnected from the transmission. However, this will increase the weight and cost of the HEV.

Weaknesses of parallel hybrid vehicles:

- Rather complicated system.
- The ICE doesn‘t operate in a narrow or constant RPM range, thus efficiency drops at low rotation speed.
- As the ICE is not decoupled from the wheels, the battery cannot be charged at standstill.

Benefits of parallel-hybrid vehicles:
• Total efficiency is more favorable during cruising and extended highway driving.
• Greater adaptability to switch between electric and ICE.
• Compared to series-hybrids, the electromotor can be designed with less power than the ICE because it is supporting traction. Only a single electric motor/generator is needed.

© 2025 IJMRSET | Volume 8, Issue 4, April 2025 |DOI:10.15680/IJMRSET.2025.0804343

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Example of a PHEV: Honda Civic. Honda's IMA (Integrated Motor Assist) utilizes a (relatively) conventional ICE with a continuously variable transmission (CVT), with the flywheel replaced with an electric motor.

Series Parallel Hybrid

In this configuration of a drivetrain, there is a combination of two of the types of drivetrain. This allows the vehicle to operate as all-electric (as a series hybrid) or it may operate as all combustion vehicle or a combination of all combustion and all electric(as a parallel hybrid). This is the most complicated and least efficient power train for most applications. Combined hybrids include some characteristics of both series and parallel hybrids. There is a double connection between the engine and the drive axle which is mechanical and electrical. This split power path allows for interconnecting mechanical and electrical power with some increase in complexity. Power-split devices are included in the power train. The power to the wheels can be mechanical or electrical or some combination of electrical and mechanical. This also holds true for parallel hybrids. But in a combined hybrid, the main principle is to decouple the power supplied by the engine from the power required by the driver.

At lower speeds, the system operates like a series HEV because, at higher speeds, the series powertrain becomes less effective, and market forces take over. The expense of this system is increased over the pure hybrid system costs due to needing an extra generator, a mechanical split power systems, and more computational ability to manage the two systems. Regardless of this expense, the system improves overall fuel use and fuel economy. This vehicle uses fuel, but the electric motor supplants or boosts the power. The costs of HEVs exceed the costs of conventional cars, but fuel efficiency and exhaust emissions are much less than conventional cars.

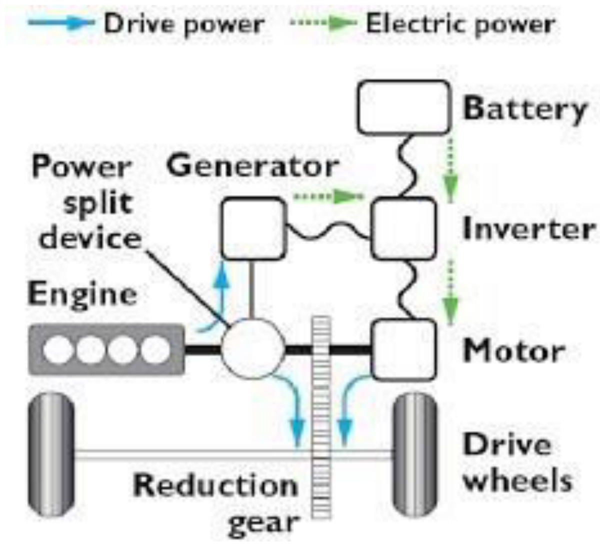


Fig No-:5 Series Parallel Hybrid

Disadvantages of combined hybrid vehicles:
Very complicated system, which is also more expensive than parallel hybrid
The efficiency of the power train transmission is solely determined by the amount of power being transmitted over the electrical path, multiple conversions with their own efficiencies result in a non-mechanical path efficiency of ~70% compared to ~98% for a mechanical path.

Benefits of combined hybrid vehicles:
Most flexible for switching between electric and ICE p•Decoupling the power traveling from the engine from the power demanded by the driver, allows for a much smaller, lighter and efficient.
ICE Example of CHEV: Toyota Prius, Auris, Lexus CT200h, Lexus RX400h.

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

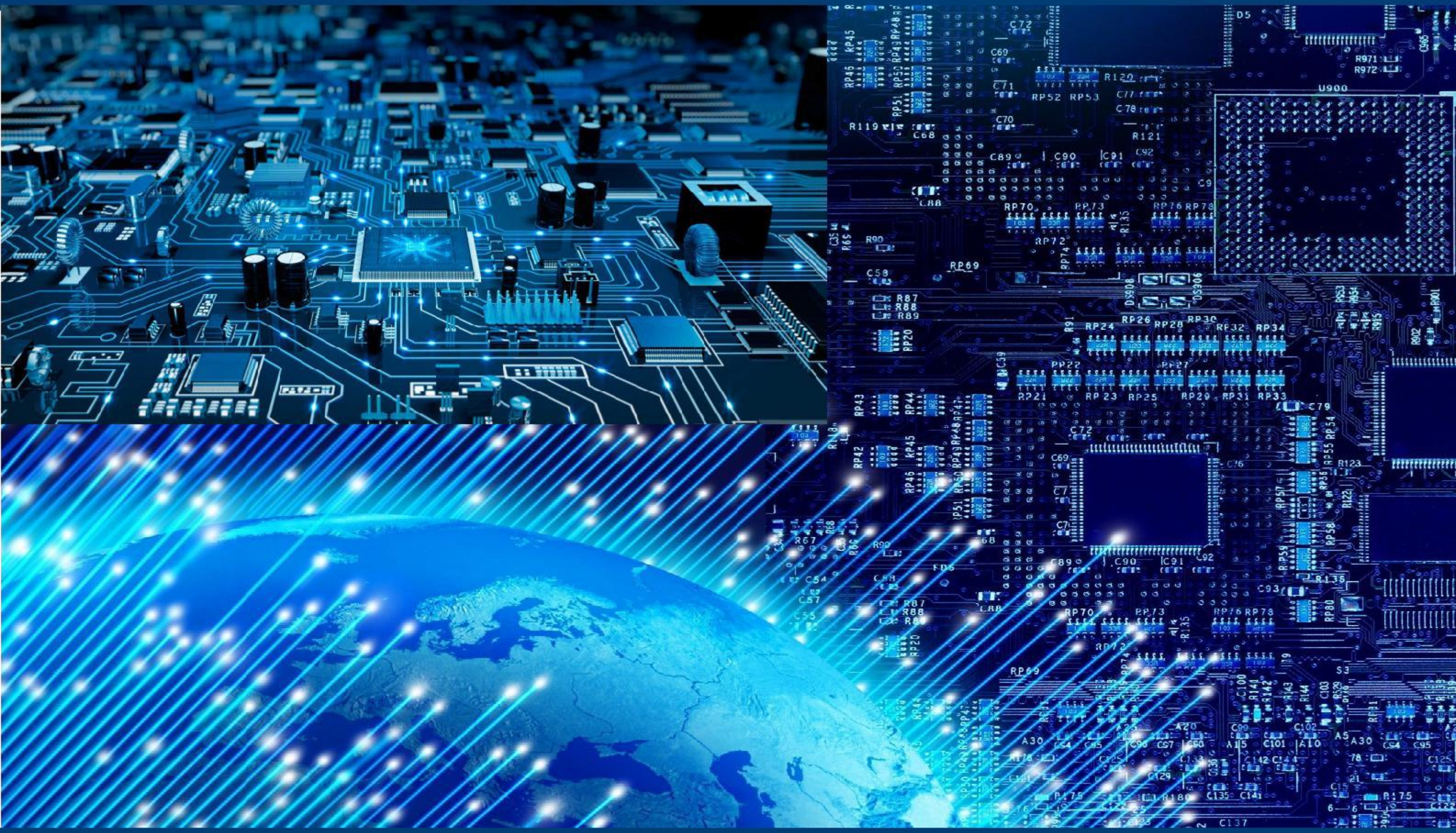
(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IV. CONCLUSION

Hybrid-electric vehicles (HEVs) merge the benefits of electric motors with those of IC engines, and can be configured such that you can gain different objectives, such as better fuel economy, added power, or extra auxiliary power for electronic devices and power tools. Transmitting the power using freewheels and chain wheels are very inexpensive and reliable. One downside is that operating on electric power is not a good option for travelling distances. However, this combined power train system can become much more utilitarian in more stop and go traffic environments. When this system is used, the overall fuel consumption and fuel economy goes up. Such a vehicle would operate of fuel but would use the electric motor to boost the power when it is needed. The costs of HEVs are slightly more than conventional cars, but they are far more efficient and have fewer exhaust emissions. Base on the increasing cost of fuel, hybrid electric vehicles can help in cost savings.

REFERENCES

[1] Zhou, Y. and Lund, P.D., 2023. Peer-to-peer energy sharing and trading of renewable energy in smart communities─ trading pricing models, decision-making and agent-based collaboration, Renewable Energy.
[2] Li, M., Zeng, Z. and Wang, Y., 2021. An innovative car sharing technological paradigm towards sustainable mobility. Journal of Cleaner Production, 288, p.125626.
[3] Zhou, Y., 2022. Low-carbon transition in smart city with sustainable airport energy ecosystems and hydrogen-based renewable-grid-storage-flexibility. Energy Reviews, p.100001.
[4] Hernandez, R.R., Armstrong, A., Burney, J., Ryan, G., Moore-O'Leary, K., Diédhiou, I., Grodsky, S.M., Saul-Gershenz, L., Davis, R., Macknick, J. and Mulvaney, D., 2019. Techno ecological synergies of solar energy for global sustainability. Nature Sustainability, 2(7), pp.560-568.
[5] Mahiban, L.N. and Emimal, M., 2023. Longevity of Electric Vehicle Operations. Qeios.
[6] van den Bergh, J.C.J.M., Castro, J., Drews, S., Exadaktylos, F., Foramitti, J., Klein, F., Konc, T. and Savin, I., 2021. Designing an effective climate-policy mix: accounting for instrument synergy. Climate Policy, 21(6), pp.745-764.
[7] Dranka, G.G. and Ferreira, P., 2020. Electric vehicles and biofuels synergies in the Brazilian energy system. Energies, 13(17), p.4423.
[8] Zhao, D., Zhou, M., Wang, J., Zhang, T., Li, G. and Zhang, H., 2021. Dispatching fuel-cell hybrid electric vehicles toward transportation and energy systems integration. CSEE Journal ofpower and Energy Systems.
[9] Boulakhbar, M., Lebrouhi, B., Kousksou, T., Smouh, S., Jamil, A., Maaroufi, M. and Zazi, M.,2020. Towards a large-scale integration of renewable energies in Morocco. Journal of EnergyStorage, 32, p.101806.
[10] Zhou, Y., 2022. Transition towards carbon-neutral districts based on storage techniques andspatiotemporal energy sharing with electrification and hydrogenation. Renewable and SustainableEnergy Reviews, 162, p.112444.
[11] Alabi, T.M., Agbajor, F.D., Yang, Z., Lu, L. and Ogungbile, A.J., 2023. Strategic potential ofmulti-energy system towards carbon neutrality: A forward-looking overview. Energy and BuiltEnvironment, 4(6), pp.689-708.
[12] Sousa, C. and Costa, E., 2022. Types of Policies for the Joint Diffusion of Electric Vehicleswith Renewable Energies and Their Use Worldwide. Energies 2022, 15, 7585.
[13] Hasan, M.M., Hossain, S., Mofijur, M., Kabir, Z., Badruddin, I.A., Yunus Khan, T.M. andJassim, E., 2023. Harnessing Solar Power: A Review of Photovoltaic Innovations, Solar ThermalSystems, and the Dawn of Energy Storage Solutions. Energies, 16(18), p.6456.
[14] Abdeljawed, H.B. and El Amraoui, L., 2021. Prospects for synergies between low-voltage DCmicrogrid technology and peer-to-peer energy trading markets. Sustainable Production andConsumption, 28, pp.1286-1296.



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com