RETROFITTING OF EXISTING HONDA ACTIVA SCOOTER INTO HYBRID SCOOTER

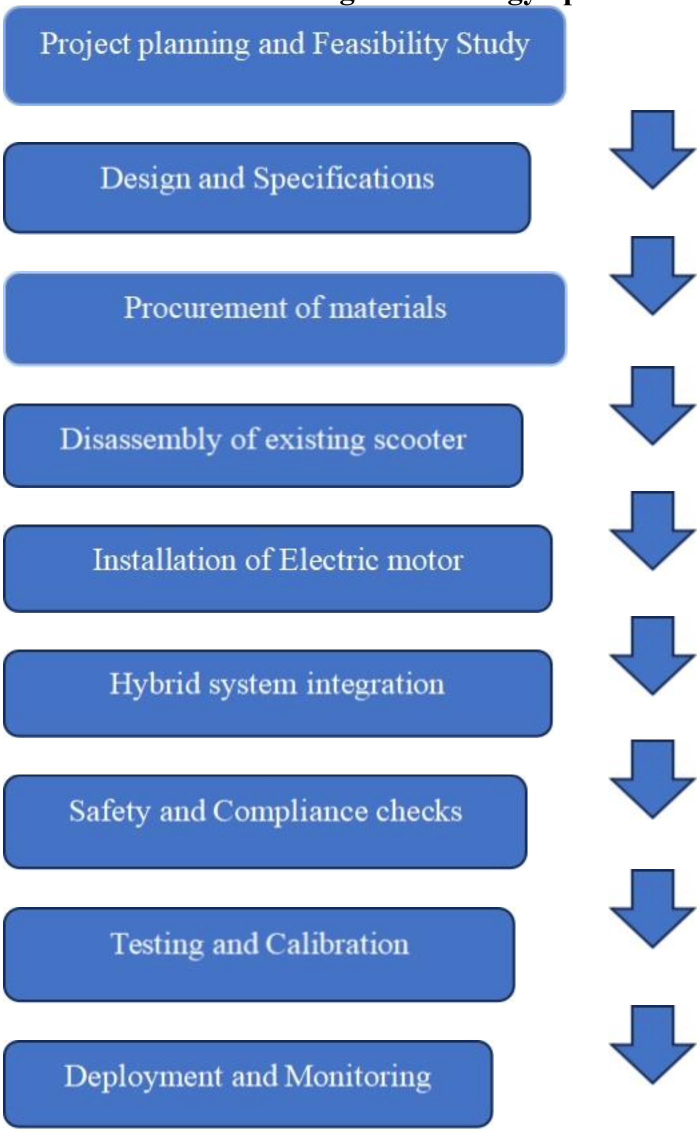
Nikhil Nampelli, Research Scholar, Department of Automobile Engineering, Maturi Venkata Subba Rao (MVSR) Engineering College, Osmania University, Hyderabad
Regula Sandeep Kumar, Research Scholar, Department of Automobile Engineering, Maturi Venkata Subba Rao (MVSR) Engineering College, Osmania University, Hyderabad

ABSTRACT
The contemporary automotive industry faces pressing challenges, particularly regarding fuel efficiency, environmental pollution, and operational inefficiency. Addressing these issues requires innovative solutions that achieve a balance between performance and sustainability. This research focuses on the development and implementation of a highly efficient, low-emission vehicle through the application of hybrid technology. Specifically, we have designed a Hybrid Electric Vehicle (HEV) model that integrates the Internal Combustion Engine (ICE) of conventional vehicles with the battery and electric motor systems characteristic of Electric Vehicles (EVs). The resulting hybrid model demonstrates a fuel economy that is twice that of traditional vehicles, achieved through the seamless integration of two propulsion systems: a petrol-based engine and an electric motor.
Our hybrid vehicle, designed in the form of a scooter, leverages both the ICE and the electric motor to drive the rear wheels. The propulsion mode is dynamically adjusted based on operational conditions to optimize efficiency. The electric system, which operates without fuel consumption and generates zero emissions, offers a significant environmental advantage. Moreover, the batteries powering the electric motor are rechargeable via a standard domestic electricity supply, enhancing both convenience and accessibility.
A unified throttle mechanism is employed to control both the internal combustion engine and the electric motor, facilitated by an advanced motor driver/controller system. This integration ensures smooth transitions between the two power sources, thereby maximizing the vehicle's overall efficiency and performance. A thorough equipment and cost analysis has been conducted to confirm the feasibility and economic viability of the hybrid scooter.
Keywords: Hybrid Electric Vehicle (HEV), Internal Combustion Engine (ICE), Electric Motor, Fuel Efficiency, Low Emission Vehicle, Hybrid Technology, Rechargeable Batteries, Propulsion Systems

I. Introduction
Human mobility is a major contributor to air pollution and climate change, prompting an urgent need for sustainable transportation solutions. In response, alternative transportation technologies have gained significant attention, with electric vehicles (EVs) emerging as a leading contender due to their potential to substantially reduce emissions. However, the widespread adoption of EVs is constrained by challenges such as high costs and limited range, highlighting the need for additional sustainable options.
One promising approach is the retrofitting of existing vehicles with hybrid systems, offering a cost-effective and environmentally friendly alternative. The project "Retrofitting of IC Engine Scooter into Hybrid Scooter" addresses this challenge by converting a conventional internal combustion engine (ICE) scooter into a hybrid vehicle. This process involves the integration of an electric motor and battery system into the existing vehicle structure, effectively combining the advantages of both electric and ICE propulsion systems. Retrofitting not only improves the environmental performance of the vehicle but also eliminates the need for new vehicle purchases, making it an economically viable solution.
The project involves several key stages, starting with the design and integration of the hybrid system. This phase requires careful consideration of the scooter's existing architecture to determine the optimal configuration of new components. Following design, extensive testing and optimization are essential

to ensure that the hybrid system performs efficiently under a range of operating conditions. The final stage involves a thorough evaluation of the environmental and economic impacts of the retrofitted scooter, providing a comprehensive assessment of its benefits and limitations.
Hybrid Electric Vehicles (HEVs), which utilize multiple energy sources, offer a balanced approach by combining the strengths of electric drives with the capabilities of ICEs. HEVs can significantly reduce fuel consumption and emissions by employing strategies such as regenerative braking, optimized power delivery, and idling avoidance. However, the development of HEVs is not without challenges, including managing multiple energy sources, optimizing battery size, and tailoring performance to specific driving cycles. Despite these hurdles, HEVs represent a significant step towards more sustainable transportation.
HEVs are categorized into series, parallel, and series-parallel configurations, each offering different benefits depending on the vehicle's intended use. A series hybrid prioritizes electric propulsion, with the ICE used solely to generate electricity, while a parallel hybrid allows both the ICE and electric motor to independently or simultaneously power the vehicle. The series-parallel hybrid combines elements of both configurations, offering flexibility in power management to meet varying driving conditions.
In summary, the "Retrofitting of IC Engine Scooter into Hybrid Scooter" project represents a critical step towards sustainable transportation by enhancing the performance and environmental friendliness of existing vehicles. Through the integration of hybrid systems, this project aims to reduce emissions, improve fuel efficiency, and provide a cost-effective alternative to purchasing new EVs. By addressing the technical, economic, and environmental challenges associated with hybrid vehicle development, this initiative contributes to the broader goal of achieving a sustainable and efficient transportation system.

III. Flow chart describing methodology opted



IV. Principle Components

4.1 Honda Activa Scooter

Parameter	Original Honda Activa 110CC
Engine	109 cc, air-cooled, 4-stroke
Power	8 bhp @ 7500 rpm
Torque	8.74 Nm @ 5500 rpm
Transmission	V-Matic
Fuel System	Carburettor
Battery	12V, 3Ah
Fuel Capacity	5.3 L
Mileage	50 kmpl
Emissions	60 g/km
Suspension	Telescopic (front) + Spring loaded hydraulic (rear)
Tyres	Tube
Weight	110 Kg
Brakes	Disc (front) + Drum (rear)

Table 4.1 Overview of Honda Activa Scooter

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Figure 4.1 - Honda Activa Scooter

4.2 BLDC Motor

Speed (RPM)	3100rpm – 3400rpm
Continuous Current(A)	20A – 30A
Efficiency	88%
Voltage(V)	48V
Output Power(W)	1200W

Table 4.2 BLDC Motor Specifications

Figure 4.2 - BLDC Motor

4.3 Chain Sprocket

NO. OF TEETH	PITCH DIAMETER (mm)	PART NUMBER	BORE		APPROX WEIGHT(KG)
			STOCK (mm)	MAX (mm)	
14	57.07	08B14	10	28	0.31
48	194.18	08B48	19	60	2.76

Table 4.3 Sprocket Specifications

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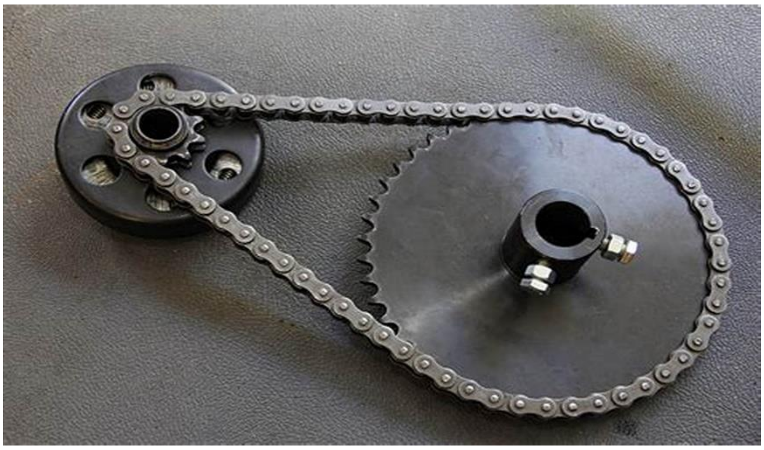

Figure 4.3 - Chain Sprocket

- The chain size is 428 to 520, and it has 52 links.

4.4 Battery

Nominal Voltage	48.1V
True Capacity	30AH at 0.2C discharge
Watt hr	1443 WH
Weight	9.75 KG
Battery Dimensions (L*W*H)	235*180*180 in mm
Full Charged Voltage	54.6V
Standard Charging Current	6A
Max Charging Current	10A
Max Continuous Discharge Current	30A
Standard Charging Temperature	0°C to 45°C
Discharge Temperature	20°C to 45°C
Storage Temperature	20°C to 45°C

Table 4.4 Battery Specifications

Figure 4.4 – Battery

4.5 Controller

Aspect	Information
Voltage	48v
Weight	1.5kg
Material	Aluminium
Current	50 amp
Rated power	900~1100
Speed	<=25kmph

Table 4.5 Controller Specifications

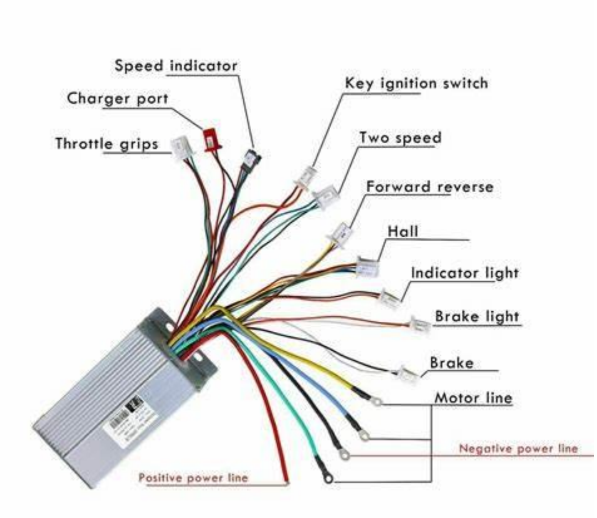

Figure 4.5 – Controller

4.6 Electric Throttle

The common acceleration throttle in hybrid vehicles simplifies control by integrating the electric motor and internal combustion engine (ICE) inputs into a single pedal. This integration optimizes performance, fuel efficiency, and emissions by allowing the vehicle's system to manage power distribution seamlessly. It also ensures smooth transitions between power sources, enhances regenerative braking efficiency, and provides consistent acceleration, making the driving experience more intuitive and efficient.

Figure 4.6 - Electric Throttle

V. Working of Hybrid Scooter

A hybrid scooter equipped with both an internal combustion (IC) engine and an electric motor, utilizing a chain and sprocket system, represents a fusion of traditional fuel-powered propulsion and modern electric drive. This configuration includes key components such as the IC engine, which typically runs on gasoline and drives the wheels through a dedicated chain and sprocket, and the electric motor, which can operate independently or in tandem with the IC engine. The motor draws power from a battery pack, which can be recharged via regenerative braking, external chargers, or the IC engine itself. A controller unit orchestrates the power distribution between these two sources, allowing the scooter to operate in various modes: solely on electric power for short, low-speed journeys; using only the IC engine for higher speeds or when the battery is depleted; or in a hybrid mode where both sources contribute to propulsion, particularly during high-demand situations like acceleration or hill climbing. The transmission system, often incorporating a simple gear mechanism, links the engine and motor to the rear wheel, either through separate or shared sprockets and chains.

The chain sprocket system plays a crucial role in transferring rotational power, with dual sprocket setups allowing independent operation of the engine and motor, or a single shared sprocket enabling integrated power delivery. This hybrid approach offers several advantages, including improved fuel efficiency by leveraging electric power for short trips, reduced emissions through increased electric usage in urban environments, and operational flexibility across different driving conditions. However, these benefits come with challenges such as increased system complexity, added weight from the combined powertrains, and higher initial costs due to the sophisticated technology involved. Overall, the hybrid system enhances the scooter's versatility, balancing the efficiency and lower emissions of electric power with the extended range and power of a traditional IC engine.

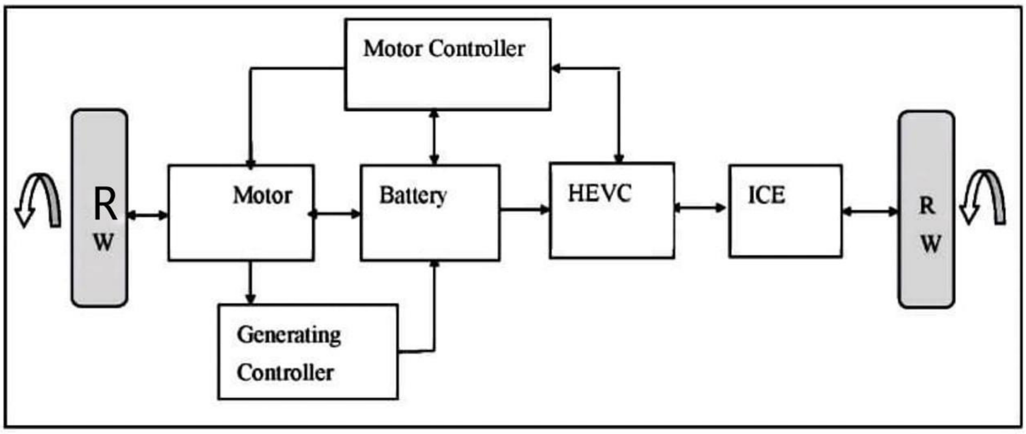

Figure 5 – Block Diagram

VI. Cost Analysis and Economic Viability

The economic viability of hybrid scooters, which combine an internal combustion (IC) engine with an electric motor, hinges on a balance of several cost factors. Initially, these scooters tend to be more expensive than traditional IC or fully electric models due to the complexity of having dual powertrains and the need for advanced components like battery packs and controllers. However, operational costs can be lower, as fuel savings are realized by using electric power for short trips and urban commuting, which can significantly reduce gasoline consumption. While electricity costs for charging the battery are minimal, the savings on fuel can, over time, offset the higher upfront cost. Maintenance costs may be higher due to the need to service both the engine and the electric motor, though the reduced strain on the IC engine and the use of regenerative braking, which lessens brake wear, can mitigate some of these expenses. Battery life is a crucial factor, as replacing the battery pack can be costly and affects long-term savings. Government incentives, tax credits, and environmental rebates can enhance the economic appeal of hybrid scooters, lowering the effective purchase price and improving the return on investment. Additionally, hybrid scooters often retain higher resale value, further contributing to their financial viability. Ultimately, while the initial cost is higher, the long-term savings on fuel, coupled with potential incentives and higher resale value, make hybrid scooters a potentially sound investment, particularly for urban commuters who can maximize the benefits of electric propulsion.

VII. Future Research and Development

Advancements in battery technology will be crucial, with efforts aimed at increasing energy density, reducing charging times, and extending battery life. Research into solid-state batteries and other next-

generation technologies promises significant improvements in the electric drive's efficiency and range. Additionally, the integration of HEVs with renewable energy sources, such as solar and wind power, will further reduce their carbon footprint, making them more sustainable.
Advanced power management systems will be developed to more effectively balance the use of electric and gasoline power based on real-time driving conditions, optimizing performance and fuel efficiency. The use of *lightweight materials* in vehicle construction will also be prioritized to reduce the overall weight of HEVs, leading to increased efficiency and lower energy consumption.
Incorporating *autonomous and connected vehicle technologies* into HEVs will enhance their efficiency by enabling optimized route planning and driving behaviours, which can reduce unnecessary fuel consumption and emissions. The *expansion of charging infrastructure*, particularly in urban areas, will be essential to support the broader adoption of HEVs and encourage consumers to transition from conventional vehicles.
Policy support and incentives from governments and regulatory bodies will play a critical role in promoting HEV adoption, through measures such as tax breaks, subsidies, and investments in charging infrastructure. Increasing *public awareness and education* about the benefits of HEVs will also be important in driving consumer demand and supporting the shift toward sustainable transportation solutions.
Further improvements in *regenerative braking systems* will enable more efficient energy capture and storage during deceleration, enhancing the range and overall efficiency of HEVs. *Hybrid engine optimization* will be another focus area, with research into more efficient designs that can seamlessly integrate with electric drives, including exploring alternative fuels like biofuels or hydrogen to further reduce emissions.
To ensure the economic viability and widespread adoption of HEVs, *cost reduction strategies* will be essential. Developing cost-effective manufacturing processes and materials will help make HEVs more affordable, particularly in emerging markets. Comprehensive *lifecycle analysis and recycling* practices will be necessary to assess and minimize the environmental impact of HEVs from production to disposal, ensuring their sustainability throughout their entire lifecycle.
Performance enhancements will also be a priority, with a focus on making HEVs competitive with traditional vehicles in terms of acceleration, handling, and overall driving experience. The development of high-performance hybrid models will appeal to a broader range of consumers. Finally, *global market expansion* efforts will address region-specific challenges, such as infrastructure limitations, regulatory differences, and consumer preferences. Collaboration with international partners will be key to introducing HEVs into diverse markets, supporting their global adoption.

VIII. Conclusions

Hybrid Electric Vehicles (HEVs) present a promising solution for enhancing automotive efficiency and reducing environmental impact through their dual-power system, which combines a gasoline engine with an electric battery. This integration allows HEVs to optimize energy use based on driving conditions, leading to significantly improved fuel efficiency—often doubling the mileage of conventional vehicles—and a substantial reduction in emissions, with up to 50% fewer greenhouse gases and pollutants. The dual-power system is particularly beneficial in urban environments, where frequent stop-and-go traffic typically increases fuel consumption and pollution with conventional engines. HEVs seamlessly switch between power sources to maximize efficiency and minimize environmental impact, making them a sustainable alternative to traditional gasoline-powered vehicles.
In this project, we explored the feasibility of retrofitting existing Honda scooters into hybrid scooters, uncovering several key insights. Effective integration of the electric motor with the internal combustion engine (ICE) is essential for successful retrofitting, requiring precise alignment, coupling, and control mechanisms. The electric motor aids during acceleration, reducing the load on the ICE and improving overall efficiency. The battery pack, a critical component, directly impacts the electric range

and performance, with its optimal placement within the scooter chassis crucial for maintaining stability and handling. Achieving balanced weight distribution between the ICE and electric motor poses a challenge, as uneven distribution can affect handling, stability, and cornering, necessitating careful scooter frame design. Additionally, the regenerative braking capability of the electric motor enhances energy recovery during deceleration, making efficient energy conversion and a seamless transition between regenerative and mechanical braking vital. Hybrid scooters require specialized maintenance, with regular checks of the electric system, battery health, and control electronics, and the training of service technicians to handle both ICE and electric components is crucial. Retrofitting existing scooters into hybrids contributes to reducing greenhouse gas emissions and promoting sustainable transportation, with advocacy for hybrid scooters likely to encourage their adoption and increase awareness. Future research should focus on optimizing hybrid scooter performance, battery technology, and cost-effectiveness, while collaborations with manufacturers, policymakers, and environmental organizations can drive wider adoption.

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