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Comparative Analysis of Energy Consumption in Conventional and Electric Cars

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***Abstract*— Transportation is one of the most important activities undertaken by humans. We use transportation to travel to different places and also for economic activity. Ever since the invention of motorized transport vehicles in the 19th century, cars, buses, trucks, and motorbikes have become irreplaceable in human society. The most popular type of motorized vehicles used until now were petroleum-based vehicles. But due to concerns regarding global warming, climate change, and depleting oil reserves, a policy change is taking place of slowing and steadily replacing petroleum-based vehicles with electric vehicles (EV). Many countries are adopting electric vehicles (EVs) as the mode of transportation to combat climate change. With the wide scale adoption of EVs, it is necessary to assess their performance against conventional vehicles to understand their effect on the environment and know their strengths and weaknesses. In this paper, the performance of electric and conventional cars is studied in terms of power requirement, torque requirement, energy consumption, and mileage. The electric and conventional cars are modeled in Simulink using vehicle dynamics. To simulate the models, a standard drive cycle FTP-75 is used. The vehicles are simulated by varying the rolling resistance coefficient of the road using the FTP-75 drive cycle. When the models are simulated using the FTP-75 drive cycle, the output of the simulation is structured and saved in excel spreadsheets. Individual spreadsheets are generated for both electric and conventional cars considered, additionally, two consolidated spreadsheets are generated for variable grade and variable rolling resistance coefficient. Extensive programming is done in MATLAB to automate the whole simulation, output generation, and plotting process.**

***Keywords*— Conventional Car; Electric Car; Modeling; FTP-75 Drive Cycle; Matlab-Simulink; Energy Consumption**

I. INTRODUCTION

The growing global concern over climate change, rising fuel prices, and urban air pollution has accelerated interest in electric vehicles (EVs) as a sustainable alternative to conventional internal combustion engine vehicles (ICEVs). In India, the government's ambition to reach 30% EV penetration by 2030 highlights the urgency and scale of this transition [2]. However, the adoption of EVs is influenced not only by policy but also by consumer attitudes and infrastructure readiness. A study focusing on India identified that a positive public attitude, supported by government incentives and awareness, plays a crucial mediating role in the EV adoption process [1].

Energy efficiency is a key factor in evaluating the viability of EVs. Compared to ICEVs, EVs exhibit significantly higher well-to-wheel (WTW) energy efficiency, especially when powered by renewable energy sources. WTW efficiency for EVs ranges from 40–70% with renewables, while ICEVs typically achieve only 11–37% efficiency depending on the fuel type [4, 10]. However, in regions with coal-dominated power grids, this advantage diminishes, making the source of electricity critical to realizing EVs' full environmental benefits [8]. Real-world driving conditions significantly affect vehicle energy consumption. Research comparing driving cycles in cities like Edinburgh and Delhi shows that driving patterns vary widely and directly impact emissions and efficiency [3]. This underlines the importance of using city-specific drive cycles to accurately assess vehicle performance [7]. Furthermore, studies conducted in geographically unique areas, such as high-altitude cities in Ecuador, demonstrate that although EVs are more energy-efficient and cheaper to operate, limitations in charging infrastructure and grid capacity still pose barriers to adoption [5].

Advancements in simulation and modelling have contributed to more accurate predictions of EV range and energy consumption. Models developed using MATLAB/Simulink show high accuracy with minimal error (2–6%), helping to reduce range anxiety among users [6]. Extended-Range Electric Vehicles (EREVs) offer a hybrid solution and show promise in varying driving conditions, although their performance also depends on electricity mix and control strategies [8]. Moreover, the integration of geared transmission systems, such as continuously variable transmissions (CVTs), has shown to enhance EV performance and energy efficiency under dynamic driving conditions [9].

1.1 Objectives

- To develop the mathematical model of internal combustion engine vehicle (ICEV) and electric vehicle (EV).
- To implement the mathematical model of ICEV and EV Cars models in MATLAB-Simulink.
- To analyze the energy consumption and fuel economy

II Methodology

2.1. Mathematical Modelling of Car

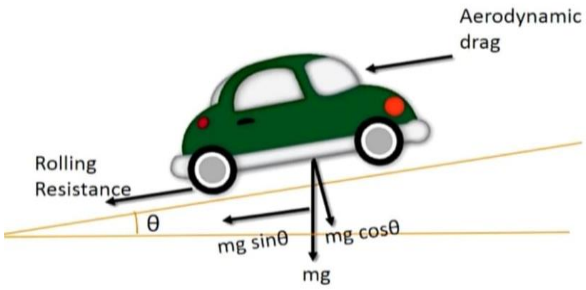

Fig. 1 Traction forces acting on a vehicle

Based on the dynamics of vehicle (car), the total tractive force (Ftrac) required to run the vehicle should overcome rolling resistance force (Froll), climbing force (Fclimb), aerodynamic dragging force (Fdrag) and provide acceleration (Fac).

$$Ftrac = Froll + Fclimb + Fac + Fdrag \quad (1)$$

$$Froll = \mu * m * g \quad (2)$$

$$Fclimb = m * g * \sin(\theta) \quad (3)$$

$$Fdrag = ½ * \rho * C_D * A_f * \quad (4)$$

$$Fac = m * dv/ dt \quad (5)$$

Tractive energy is a primary factor in determining fuel consumption, and the tractive power required to move a vehicle forward at each instant in time is determined by the particular operating conditions experienced.

$$Ptrac = Ftrac * v \quad (6)$$

Energy, $E = \frac{1}{3600}\int_0^t Ptr$ in watt-hours (7)

OR

Energy, $E = \int_0^t Ptr.dt$ in joules (8)

Fuel consumption,

$$L = \frac{E}{31526000} \text{ in litres of petrol} \quad (9)$$

From this torque can be calculated as:

$$T = \frac{Ptr}{\omega} \quad (10)$$

Where,
m = vehicle mass in kg
v = speed in m/s
g = gravitational constant
θ = grade
C_D = coefficient of drag
A_f = vehicle frontal area
ρ = air density
μ= coefficient of tire rolling resistance
ω = speed in RPM

2.2. Simulink Modelling

Simulink is a MATLAB-based graphical programming environment for modelling, simulating, and analysing multi-domain dynamical systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in automatic control and digital signal processing for multi-domain simulation and model-based design. Simulink Verification and Validation enables systematic verification and validation of models through modelling style checking, requirements traceability, and model coverage analysis. Simulink Design Verifier uses formal methods to identify design errors like integer overflow, division by zero, and dead logic and generates test case scenarios for model checking within the Simulink environment [11, 12].

III. VEHICLE DYNAMICS SIMULINK MODELS

3.1. Electric Vehicle Model

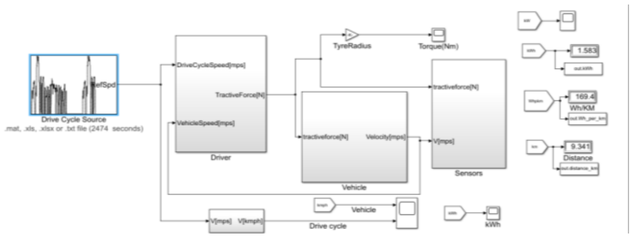

Fig. 2 Electric Vehicle Model

The Electric vehicle model of the Electric car is given in figure 2. It consists of drive cycle blocks, a Driver block, a vehicle dynamics block, and finally a sensors and calculations block. The model also consists of several scopes to display the various quantities.

3.2. Conventional Vehicle Model

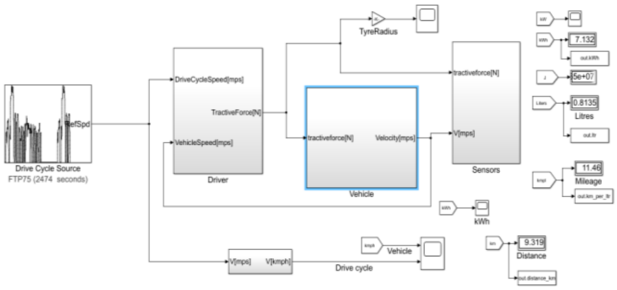

Fig. 3 Conventional vehicle model

The Conventional vehicle model of the conventional car is given in figure 3. It consists of various drive cycle blocks, a Driver block, a vehicle dynamics block, and finally a sensors and calculations block. The model also consists of several scopes to display the various quantities. The drive cycle, driver block, vehicle dynamics block are same in both electric and conventional vehicle models only sensor and calculation blocks are different.

3.3. Drive Cycle Block

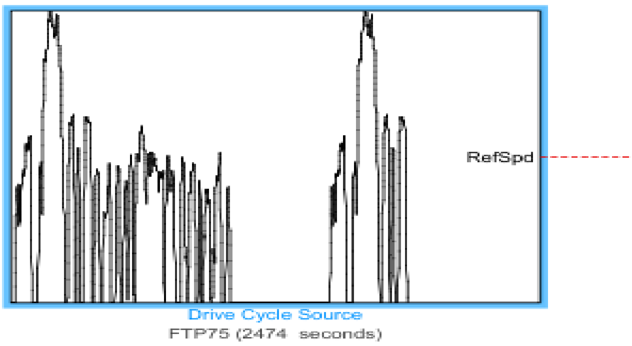

Fig. 4 Drive Cycle Block

Figure 4 shows the Environmental Protection Agency (EPA) Federal Test Procedure, commonly known as FTP-75 for the city driving cycle, are a series of tests defined by the US Environmental Protection Agency (EPA) to measure tailpipe emissions and fuel economy. It covers a distance of 17.7 km. The average speed and maximum speed is 34.12km/h and 91.25km/h and the total duration is 1877 seconds.

3.4. Driver Block

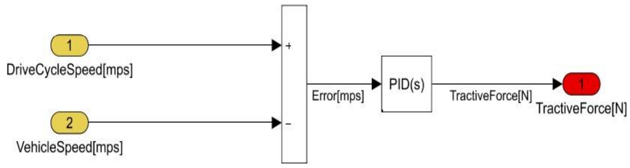

Fig. 5 Driver Block

The driver block (Fig, 5) is essentially a PID controller. It compares the drive cycle speed and vehicle feedback speed and generates an error signal. The error signal is given to the PID controller which then generates a tractive force (N) signal. This tractive force signal is given to the vehicle dynamics block to drive the vehicle.

3.5. Vehicle Dynamics block

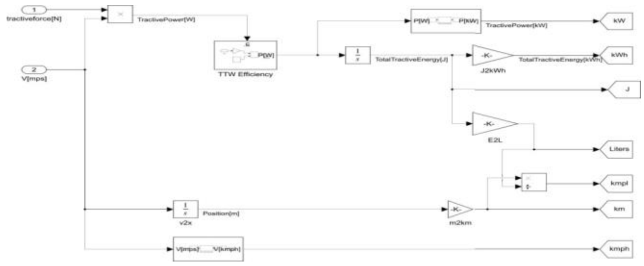

Fig. 6 Vehicle Dynamics Model

The Vehicle dynamics block (Fig, 6) implements the vehicle dynamics of the vehicle and compute various parameters such as acceleration and velocity of the vehicle. It outputs the vehicle's velocity. The vehicle dynamics block considers all the longitudinal vehicle dynamics forces on the vehicle.

3.5. Sensors Block of Electric Vehicle

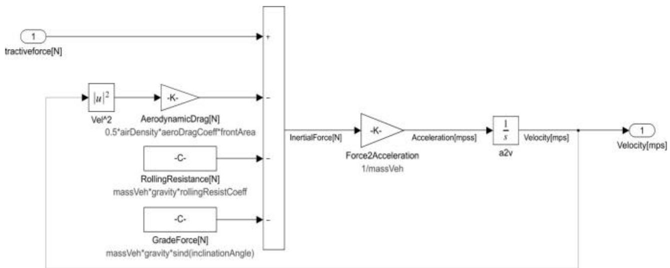

Fig. 7 Sensors Block of Electric vehicle

The sensors block (Fig, 7) takes in tractive force and vehicle velocity as inputs and computes the vehicle's total tractive power, total energy consumption, distance travelled, mileage, and outputs them. The block

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considers a battery-to-wheel (BTW) efficiency of 65%. These are then displaced in the scopes available in the model. This block also performs various conversions for quantities involved.

3.5. Sensors Block of Conventional Vehicle

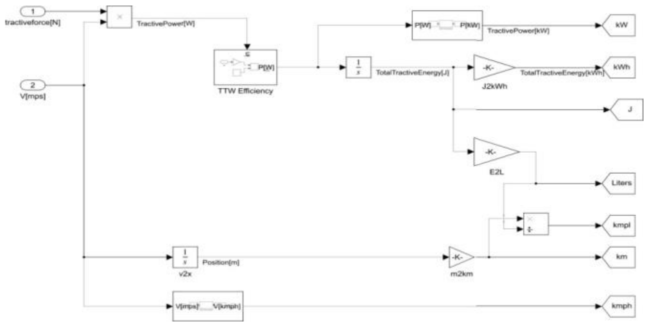

Fig. 8 Sensors Block of Conventional vehicle

The sensors block (Fig, 8) takes in tractive force and vehicle velocity as inputs and computes the vehicle's total tractive power, total energy consumption, distance travelled, mileage, fuel consumption in liters and outputs them. The block considers tank-to-wheel efficiency (TTW) of 23.5%. These are then displaced in the scopes available in the model. This block also performs various conversions for quantities involved.

IV RESULTS AND DISCUSSION

4.1.Drive Cycle

The FTP-75 (Federal Test Procedure-75) is a standardized drive cycle developed by the United States Environmental Protection Agency (EPA) to measure vehicle emissions and fuel economy in a controlled laboratory environment. This drive cycle simulates typical urban driving conditions The FTP-75 drive cycle [14] consists of three phases, these are Cold Start, and Transient Phase and Hot Start Each phase includes frequent stops, idling, acceleration, and deceleration closely mimicking stop-and-go traffic in city conditions. It provides a realistic representation of urban driving, making it suitable for comparing energy consumption between Electric Vehicles (EVs) and conventional vehicles. Table 1 shows the drive cycle parameters used in this study.

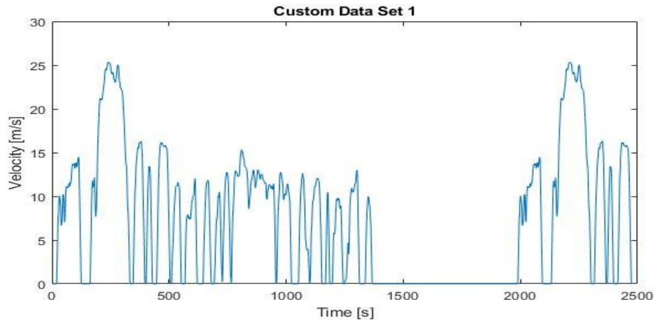

Fig. 9 FTP-75 Drive Cycle

Table 1 Drive cycle parameters

Sl. No	Parameter	Value	Units
1	Duration	1874	Sec
2	Distance	17700	m
3	MaximumSpeed	25.3	m/s
4	AverageSpeed	9.722	m/s
5	Averageacceleration	1.46	m/s^2
6	Average deceleration	-1.44	m/s^2
7	Proportion idling	27	%
8	Proportion cruising	20	%
9	Proportion acceleration	23	%
10	Proportion deceleration	30	%

4.2. Simulation

4.2.1 Simulation for variable rolling resistance coefficients and constant grade

The simulation results for variable rolling resistance coefficients are given in table 2and 3. The grade was kept at a constant value of 0 degrees to indicate a level road. The models were simulated using the FTP-75 drive cycle. The duration of the simulation was 2400 seconds. The total distance travelled was 17.7 km. The electric vehicle was assumed to have a BTW efficiency of 65%. The BTW and TTW efficiencies are derived from. [4]

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Vol. 14 Issue 08, August - 2025

Table 2 Electric Vehicle Simulation Data

MG WINDSOR (Electric Car)				
Rolling Resistance	Max Power(kW)	Max Torque(Nm)	Mileage(Wh/km)	Energy(kWh)
0.013	35.34096907	1096.749379	164.8410627	2.809626464
0.02	37.67939938	1144.290009	223.5992359	3.808655914
0.025	39.49408965	1178.135594	265.551793	4.520972321
0.05	48.56751598	1347.366151	475.3530679	8.073369681

Table 3 Conventional Vehicle Simulation Data

MARUTHI SUZUKI SWIFT (Conventional Car)						
Rolling Resistance	Max Power(kW)	Max Torque(Nm)	Litre	Mileage (km/ltr)	Mileage (Wh/km)	Energy (kWh)
0.013	22.38437178	533.4189624	0.613202059	27.79527552	315.4136031	5.375947359
0.02	23.41690328	555.4521191	0.776409954	21.94485933	399.5016722	6.806792276
0.025	24.15459564	571.1896617	0.892884292	19.07746794	459.547778	7.82792373
0.05	28.22453741	649.9228501	1.474614736	11.53711536	759.8960164	12.92795919

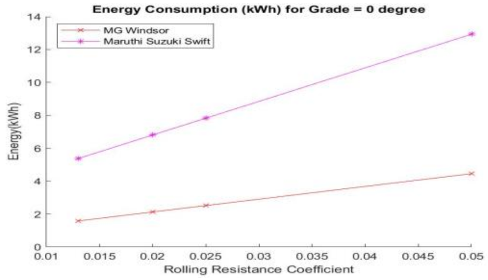

Fig. 10 Energy consumption for variable rolling resistance coefficients and constant grade

Tables 2 and 3 present the simulation results of MG Windsor and Maruthi Suzuki Swift under different rolling resistance coefficients, with the road grade kept constant at 0°. As the rolling resistance increases, both vehicles show an increase in energy consumption, power, and torque. MG Windsor's energy consumption rises from 2.81 kWh to 8.07 kWh, while the Swift's increases from 5.38 kWh to 12.93 kWh. Despite having a higher weight, the MG Windsor consistently consumes less total energy. However, in terms of mileage (Wh/km), the Swift exhibits higher values, indicating lower energy efficiency per kilometer compared to MG Windsor. The data also shows that electric vehicles offer higher torque and power outputs, making them more responsive under increasing resistance conditions. This highlights the superior energy efficiency and torque performance of electric vehicles on flat roads, even as rolling resistance increases.

Figure 10 illustrates the variation in total energy consumption of both MG Windsor (Electric Vehicle) and Maruthi Suzuki Swift (Conventional Vehicle) as the rolling resistance coefficient increases from 0.013 to 0.05 on a level road. The MG Windsor shows an increase in energy consumption from 2.81 kWh to 8.07 kWh, while the Swift's energy usage increases from 5.38 kWh to 12.93 kWh. This trend indicates that both vehicles require more energy to overcome higher rolling resistance. However, MG Windsor consistently consumes less total energy than the Swift at each resistance level, mainly due to its higher drivetrain efficiency and regenerative braking capability. This confirms the electric vehicle's advantage in reducing overall energy consumption under similar driving conditions.

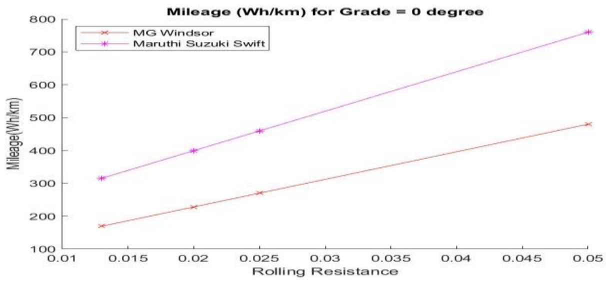

Fig. 11 Mileage for variable rolling resistance coefficients and constant grade

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Vol. 14 Issue 08, August - 2025

Figure 11 compares the mileage of the MG Windsor and Maruthi Suzuki Swift in terms of energy consumed per kilometer (Wh/km) for different rolling resistance values. As rolling resistance increases, mileage decreases for both vehicles, meaning more energy is required to travel the same distance. The MG Windsor's mileage increases from 164.84 Wh/km to 475.35 Wh/km, whereas the Swift's mileage rises from 315.41 Wh/km to 759.89 Wh/km. The lower Wh/km values for MG Windsor at all levels indicate that the electric vehicle is more energy-efficient per kilometer than the Swift. Despite the MG Windsor being heavier, its electric drivetrain and better torque control result in superior mileage performance under increasing road resistance.

4.2.2 Simulation for variable grade and constant rolling resistance coefficient

The simulation results for variable grade and constant rolling resistance coefficients are given in table 4 and 5. The rolling resistance coefficients were kept at a constant value. The models were simulated using the FTP-75 drive cycle. The duration of the simulation was 2400 seconds. The total distance travelled was 17.7 km. The electric vehicle was assumed to have a BTW efficiency of 65%. The BTW and TTW efficiencies are derived from [4].

Table 4 Electric Vehicle Simulation Data

MG WINDSOR (Electric Car)				
Grade	Max Power(kW)	Max Torque(Nm)	Mileage(Wh/km)	Energy(kWh)
0	35.34096907	1096.749379	164.8410627	2.809626464
1	41.47554082	1214.848997	311.3040971	5.297123291
2	47.80519166	1333.14392	457.7275992	7.775752996
3	54.13621018	1451.017847	604.0447183	10.24392285
4	60.62676344	1569.096246	750.2737639	12.70265063
5	68.66556196	1686.708153	896.2577317	15.148504
6	76.69432058	1804.325758	1042.061707	17.58327729
7	84.70721283	1921.848141	1187.599193	20.0053073

Table 5 Conventional Vehicle Simulation Data

MARUTHI SUZUKI SWIFT						
Grade	Max Power(kW)	Max Torque(Nm)	Litre	Mileage (km/ltr)	Mileage (Wh/km)	Energy (kWh)
0	22.38437178	533.4189624	0.613202059	27.79527552	315.4136031	5.375947359
1	24.95862833	588.3522604	1.019917737	16.69678968	525.0714759	8.941626956
2	27.71448391	643.2676207	1.425738968	11.93396852	734.6263719	12.49946494
3	31.90618504	698.1500703	1.830615337	9.286398479	944.0697618	16.0490193
4	36.0936162	752.9814978	2.234563565	7.601079786	1153.389814	19.59043665
5	40.27635849	807.7467968	2.637195696	6.435007546	1362.392808	23.12031577
6	44.45792856	862.4730729	3.03844776	5.580371113	1571.0439	26.63809582
7	48.62174692	917.0104869	3.438264011	4.927215451	1779.30275	30.14328809

Table 4 and 5 shows the effect of increasing road gradient on MG Windsor (EV) and Maruthi Suzuki Swift (ICEV) keeping rolling resistance constant. As the gradient increases from 0° to 7°, both vehicles require more energy, with MG Windsor's energy consumption rising from 2.81 kWh to 20.01 kWh, and Swift's from 5.38 kWh to 30.14 kWh. Despite higher torque and power demands, MG Windsor remains more energy-efficient per kilometer, offering better mileage (Wh/km) at all gradients. The electric vehicle also demonstrates stronger torque output, making it more effective on inclined roads. This confirms the superior uphill performance and efficiency of EVs under varying gradient conditions.

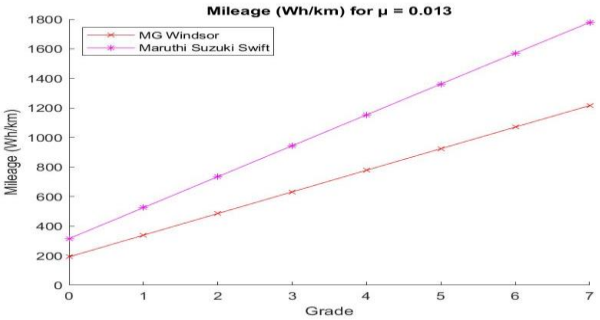
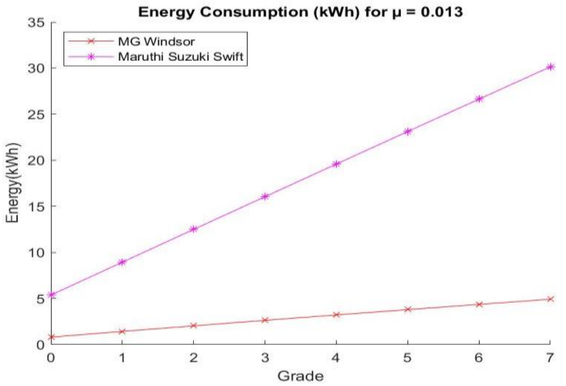


Fig. 12 Energy Consumption for variable rolling resistance coefficients and constant grade

Figure 12 presents the total energy consumption of both MG Windsor and Maruthi Suzuki Swift as the road gradient increases from 0° to 7°, while maintaining a constant rolling resistance coefficient. The energy consumption of the MG Windsor increases sharply from 2.81 kWh at 0° grade to 20.01 kWh at 7° grade. Similarly, the Swift's energy consumption rises from 5.38 kWh to 30.14 kWh. This trend is expected, as climbing steeper slopes requires more energy to overcome the component of gravity acting against the motion of the vehicle.

Although both vehicles show increasing energy demand with higher gradients, MG Windsor consistently consumes less total energy than the Swift at all grades, highlighting the electric vehicle's advantage in energy efficiency due to its regenerative braking and optimized electric drivetrain.



Fig, 13 Mileage for variable grade coefficients and constant rolling resistance

Figure 13 illustrates the variation in mileage, expressed in Wh/km, for both vehicles as the road gradient increases. The MG Windsor's mileage decreases (i.e., Wh/km increases) from 164.84 Wh/km at 0° to 1187.60 Wh/km at 7°, while the Swift's mileage drops from 315.41 Wh/km to 1779.30 Wh/km. This indicates that both vehicles become less energy-efficient as the gradient increases. However, MG Windsor maintains better mileage performance compared to the Swift at all grades. This reinforces the advantage of electric vehicles in maintaining energy efficiency even under increased load conditions, primarily due to efficient torque distribution and reduced mechanical losses.

V. CONCLUSION

This work presents a comparative analysis of energy consumption between a conventional internal combustion engine vehicle (Maruthi Suzuki Swift) and an electric vehicle (MG Windsor) using MATLAB-Simulink simulations under the FTP-75 standard drive cycle. Simulations were performed across different road conditions by varying rolling resistance and gradient. The results revealed that the MG Windsor consumed less total energy than the Maruthi Suzuki Swift in all test scenarios. For example, at a rolling resistance coefficient of 0.013 and 0° gradient, the MG Windsor consumed 2.81 kWh of energy, while the Swift consumed 5.38 kWh.

As the road gradient increased from 0° to 7°, the total energy consumption of the MG Windsor rose sharply from 2.81 kWh to 20.00 kWh, whereas the Swift's energy consumption increased from 5.38 kWh to 30.14 kWh. This demonstrates that both vehicles require more power at higher gradients, but the electric vehicle still consumes less total energy. In conclusion, MG Windsor offers lower overall energy consumption due to better battery-to-wheel efficiency (65%). This comparison highlights the trade-off between total energy usage and energy efficiency per distance, and points to areas where electric vehicles can be further optimized in design and performance.

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ABBREVIATIONS

The following abbreviations are used in this manuscript:

ICEV - Internal Combustion Engine Vehicle
EV - Electric Vehicle
FTP-75 - Federal Test Procedure-75
EPA - Environmental Protection Agency
WTW - Well-To-Wheel
TTW - Tank-To-Wheel
BTW - Battery-To-Wheel

REFERENCES

1. Anil Khurana, V. V. Ravi Kumar, Manish Sidhpuria, "A Study on the Adoption of Electric Vehicle in India: The Mediating Role of Attitude" *SAGE*, Vol. 25, No. 1, pp. 23 -34, March 2020.
2. AbhinavSoman, HarsimranKaur, Himani Jain, KarthikGanesan, "India's Electric Vehicle Transition",*Council on Energy, Environment, and Water (CEEW) report*, November 2020.
3. WafaaSaleh, Ravindra Kumar, Anil Sharma, "Driving cycle for motorcycles in modern cities: Case studies of Edinburgh and Delhi", *World Journal of Science, Technology and Sustainable Development*, Vol. 7, No. 3, pp. 263-274, August 2014.
4. Aiman ALBATAYNEH, Mohammad N. ASSAF, Dariusz ALTERMAN, Mustafa jaradat "Comparison of the Overall Energy Efficiency for Internal Combustion Engine Vehiclesand Electric Vehicles", *Environmental and Climate Technologies*, 2020, vol. 24, no. 1, pp. 669–680
5. David Sebastian Puma-Benavides, Alex Santiago CevalloCarvajal. "Comparative Analysis of Energy Consumption between Electric Vehicles and Combustion Engine Vehicles in High-Altitude Urban Traffic.", *World electric vehicle journal*, 2024, 15, pp. 355.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 08, August - 2025

6. IlyesMiri, Abbas Fotouhi, Nathan Ewin."Electric vehicle energy consumption modelling and estimation—A case study"*International journal of Energy Research*, 2021, pp. 501-520
7. AJia Di Yang 1,2, Jason Millichamp 1,2, Theo Suter 1,2, Paul R. Shearing 1,3 , Dan J. L. Brett 1,2,3 and James B. Robinson."A Review of Drive Cycles for Electrochemical Propulsion".*Energies*,2023, 16, 6552.
8. PawełKrawczyk ,ArturKopczy ´nski and JakubLasocki."Modeling and Simulation of Extended-Range Electric Vehicle with Control Strategy to Assess Fuel Consumption and CO2 Emission for the Expected Driving Range", *International Journal of Engineering Research & Technology (IJERT),* Vol. 2 Issue 11, November - 2013
9. Ahmed Elmarakbi, Adrian Morris, QinglianRen and Mustafa Elkady."Modelling and Analyzing Electric Vehicles with Geared Transmission Systems: Enhancement of Energy Consumption and Performance", *International Journal of Engineering Research & Technology (IJERT),* Vol. 2 Issue 11, November – 2013
10. S. Gopiya Naik and Syed Mohammed Mustafa Nabi, "A comparative analysis of energy consumption in conventional and electric vehicles", *International Journal of Vehicle Performance*, Vol. 10, No. 2, 2024.

11 https://en.wikipedia.org/wiki/MATLAB

12. https://en.wikipedia.org/wiki/Simulink
13. https://en.wikipedia.org/wiki/Microsoft_Excel
14. https://en.m.wikipedia.org/wiki/FTP-75