Electric Vehicle Energy Management Strategy Geared to Smart Cities

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ABSTRACT
The Electric Vehicle (**EV)** has shown potential for reducing pollution and conserving fuel. The solution saves gasoline, making developing the correct Energy Management Strategies (**EMS**s) for EVs difficult. Achieving effective power distribution requires meeting design requirements, which can be challenging. Due to the large number of EMSs presented in the literature, it is necessary to categorize them to correctly identify their design and control contributions, with an emphasis on fuel efficiency, power provisioning and real-time applicability. This study aimed to design and construct an **EMS** for **EV** powertrains. Indeed, electric vehicles use power electronic components and electric motors to manage energy flow between powertrain subsystems and supply the necessary torque and power to the wheels. The proposed subsystems generate undesired electrical harmonics on the DC bus of the powertrain. Conducting statistical analysis of the high rate of pollution and the increasing demand for electric vehicles seeks to manage energy consumption. The obtained findings established the recommended strategy's credibility.

Keywords: *Electric vehicle, modeling, Energy management, Electric storage.*

1. INTRODUCTION

EVs combine an internal combustion engine (ICE) and an electric motor. EVs appear to be the most economically viable answer to date and likely for the foreseeable future. The overall goal of developing EVs is to reduce fuel consumption and emissions while meeting drivers' energy demands through research into efficient EMSs. Energy management strives to achieve appropriate energy partitioning in the face of difficult situations. To improve driving conditions and reduce fuel consumption and pollutants. It is widely accepted that gains in the fuel efficiency of hybrid vehicles, and thus in reducing their emissions, depend heavily on energy management strategies (EMS) [1]. The complex setup and behaviour of multi-source hybrid power systems place additional requirements on the operation of energy management systems (EMSs). Regardless of powertrain design, the EMS manages the transducer power flows in real-time to achieve control objectives [2]. Thus, the optimal control algorithms used during a driving cycle serve as a representative study scheme in energy management techniques. In [3], the authors report that EMS was chosen as a potential research issue for industries and academics performed. There are numerous classifications of approaches to energy management in the assessments of the available literature. EMSs are categorized into three types based on their optimization strategy: rules-based, local, and global. In [4], the authors provide an overview of energy management systems (EMSs) for plug-in hybrid electric vehicles. The classification of energy management, including both rule-based and optimization-based control systems, is discussed. In [5], the authors compare the advantages and disadvantages of each technique. Finally, many aspects of real-time implementation (for example, computational burden and optimization) are discussed. In [6], the authors examine and present various classifications of hybrid vehicles that use the hydraulic drive—classifying and comparing Internet-related technologies. New EMS are being created to address increasing performance needs as ITS technologies and machine learning methodologies advance (e.g., adaptability and real-time execution) [7]. However, a complete evaluation of EMS is required to grasp present techniques and future research endeavours better. Unlike previous EMS examinations, this one contains a complex hierarchical ranking system. There are two sorts of offline EMS: those based on global improvement and those based on regulations [8]. Immediate improvement, predictive improvement, and learning-based improvement are the three online environmental management systems types. Because the suggested technique encompasses a variety of methodologies in terms of solution objectives, optimization, and real-time implementation, a thorough review of the literature is required. Compare each technology's concept, benefits, and downsides and highlight the proposed scheme's design and operating characteristics [10]. Finally, the development of novel EMS and recent literature highlights critical prospects for large molecules.

This paper describes a realistic environmental management system for electric vehicles. The proposed approach is developed in response to various constraints, including energy demands and subsystems. Unlike previous papers, it avoids clustering (on/off), global/local optimization, which can be deceptive due to algorithm modifications and implementation assumptions. Instead, each algorithm is presented and reviewed individually, emphasizing its advantages and limitations, as well as alternative techniques to compensate for them.

2. EV MODELING

Series, parallel, and power splitting are the three most common structures for electric vehicles. For many people, a hybrid powertrain is simply a battery-only electric vehicle with a hybrid powertrain. The motor drives a generator that generates electricity mixed with electricity from the energy storage system and transmitted to the electric motors of the wheels [11]. The advantage of a sequential hybrid powertrain is that it only needs electrical connections between the PTOs. As a result, packaging and design are simplified. The engine may operate in a high-efficiency area since it is pretty far from the wheels. However, even when the machine is attached directly to the wheels, the sequential hybrid powertrain involves two power conversions (mechanical to electrical in the alternator and electrical to automatic in the engine), resulting in a loss of efficiency. As a result, a serial hybrid electric vehicle consumes more fuel than a standard vehicle, especially when travelling on highways. One of the two electromechanical transducers must also be sized to fit the vehicle's maximum power demand. The chain topology is illustrated in Figure 1.

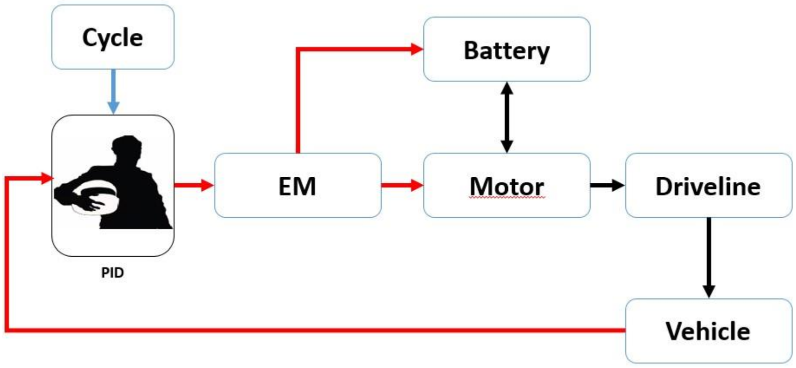

Figure 1: Architecture of vehicle model

2.1 Vehicle Model

Although the vehicle equation is implemented using Tractive Force, the first step is to depict the forces acting on the EV in the Figure 2. EV parameters are shown in Table 1.

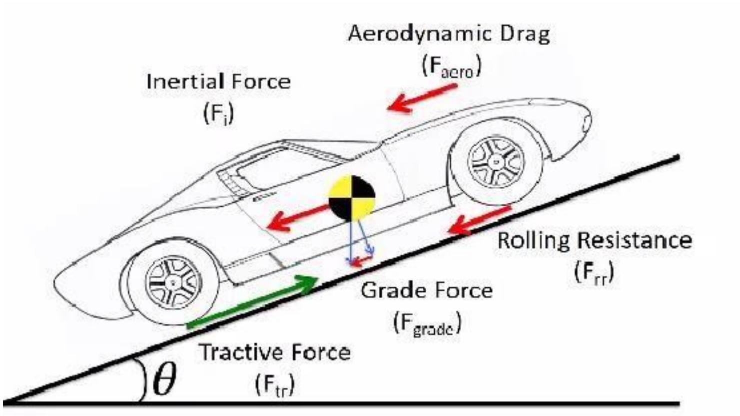

Figure 2: All tractive force of vehicle

$$F_{tr} = F_{aero} + F_i + F_{arade} + F_{rr} \quad (1)$$

$$F_{arade} = \frac{1}{2}\rho C_d A_f V^2 \quad (2)$$

$$m_i = \alpha m_i \quad (3)$$

$$\alpha = \frac{F_{tr} - (F_{aero} + F_{grade} + F_{rr})}{m_i} \quad (4)$$

$$F_{grade} = mg\sin(\theta) \quad (5)$$

$$F_{rr} = mgC_{rr} \quad (6)$$

Table 1: EV Parameters

Parameter	Value	
ρ	1.2 K_g/m^3	Air density
C_d	0.38	Drag coefficient
A_f	2.1 m^2	Vehicle frontal area
m_i	2080 K_g	Vehicle inertial mass
m	2000 K_g	Vehicle mass
g	9.8 m/s^2	gravity
θ	0 degrees	Road angle
C_{rr}	0.01	Rolling resistance coefficient

2.2 Battery Model

The battery model is a sort of equivalent circuit that has a voltage source and an internal resistance. Battery parameters are shown in Table 2.

$$I = V_{oc} - \sqrt{\frac{V_{oc}^2 - 4R_{int}P_{actual}}{2R_{int}}} \quad (7)$$

$$V_{term} = V_{oc} - IR_{int} \quad (8)$$

$$SOC_{new} = SOC_{old} + 100\left(\frac{dE_{int}}{E}\right) \quad (9)$$

$$P_{ideal} = P_{actual} + P_{loss} \quad (10)$$

$$P_{loss} = I^2 R_{int} \quad (11)$$

$$P_{ideal} = IV_{OC} \quad (12)$$

$$P_{actual} = IV_{OC} - I^2 R_{int} \quad (13)$$

Table 2. Battery Parameters

Parameter	Value
I	3.6 A
V	360 V
R_{int}	0.01 Ω
SOC	95%

3. ENERGY MANAGEMENT APPROACH

EMS is considered the most important in a vehicle; it has the potential to improve a vehicle's energy efficiency, cost and speed. The power management system must regulate the energy flow between the storage system and, in turn, the power train, with the aim of reducing battery current and capturing braking energy during various driving phases, particularly in urban cycles. There are three basic ways to optimize energy consumption:

- Dynamic programming methods: require distinct initial and final conditions. However, these methods are applied in predetermined cycles [12].

- Optimal control methods helped reduce the analytic expression of the energy subject to constraint [13]. This is often a challenging task that requires a long period of calculus to complete.

Intelligent technologies, such as or neural networks, are proposed to overcome the limitations of the previous two methods [14]. These techniques take a long time to implement and necessitate the use of a powerful DSP. In this article, we will explain how to use the first method with a simple algorithm based on the battery charge state, speed and brake position. The EM algorithm was chosen to reduce the speed of battery power consumption. When the brakes are applied, the acceleration is disabled, the battery charge status is between 25% and 95%, the EM starts to slow down, and the battery recharges, just as it would in mode 1. However, if the battery charge status should be less than 25%, it should Engage the brakes and deactivate the acceleration. The car will come to a complete stop, and mode 2 is indicated. Finally, if acceleration is enabled, the brakes are disabled, the vehicle accelerates, and that is mode 3. The proposed Energy Management System is shown in Figure 3.

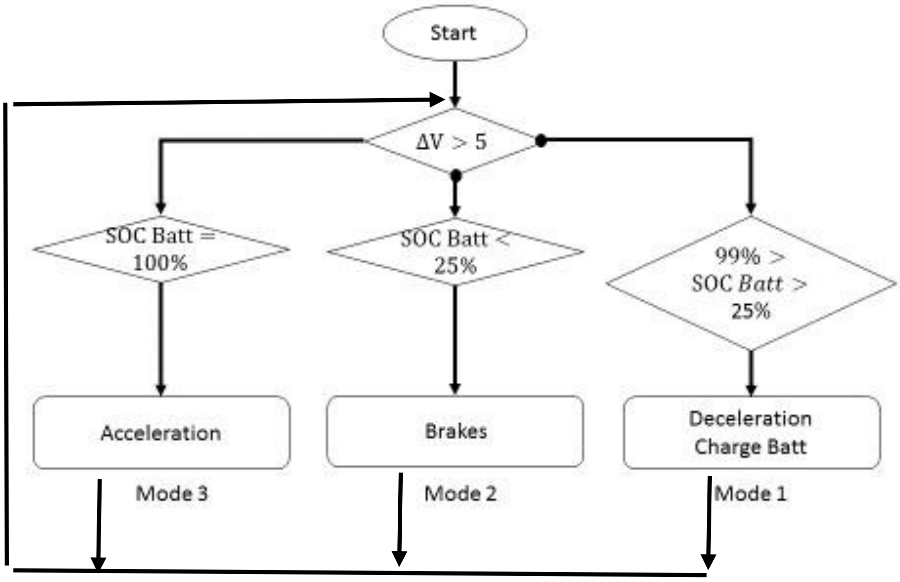

Figure 3: Proposed Energy Management System

4. SIMULATION RESULTS AND DISCUSSION

The BEV model was validated in MATLAB-Simulink using the UDDS (Dynamometer Urban Driving System) and NEDC (New European Driving Cycle) driving tables. A UDDS cycle is defined as a maximum speed of 80 kilometres per hour and an average speed of 58 kilometres per hour. The vehicle was exposed to this cycle for 600 s (See Figure 4 (a)). The NEDC cycle is defined by a top speed of 70 kilometres per hour, an acceleration of 1.04 kilometres per second, and an average speed of 33.3 kilometres per hour. During the 700s, this cycle was applied to the vehicle (See Figure 4 (b)).

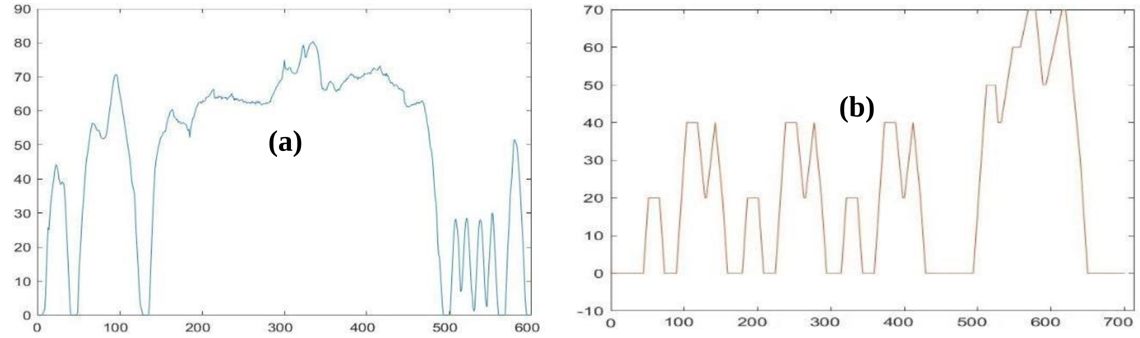

Figure 4: UDDS cycle: **(a)** 58Km/h, **(b)** 70 Km/h

The power generated by the battery to propel the electric vehicle reaches 111,461 kilowatts when the EV is operating at total capacity. However, when the battery power graph is below zero. This indicates that the battery is charging (See Figure 5.) When we compare the NEDC cycle's battery power to that of the UDDS cycle, we see that the NEDC cycle has more disturbance. The EM algorithm compels the battery to generate additional power (See Figure 6).

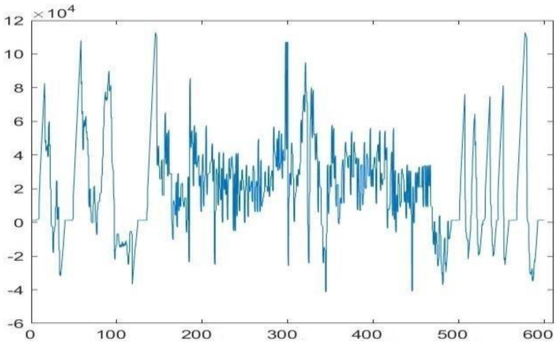

Figure 5: Batterie power (UDDS cycle)

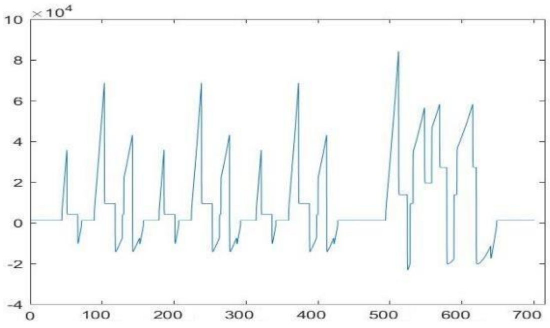

Figure 6: Battery power (NEDC cycle)

When comparing the NEDC and UDDS cycles in terms of battery power, we see that the NEDC cycle produces a more significant perturbation (See Figure 7). The EM algorithm forces the battery to generate additional power (See Figure 8).

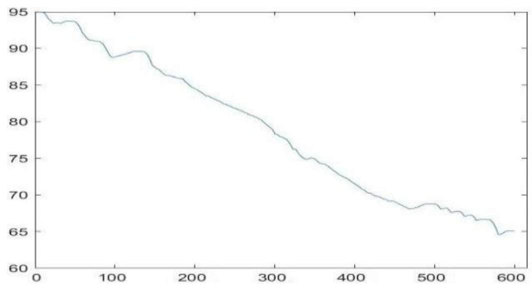

Figure 7: SoC-battery (UDDS cycle)

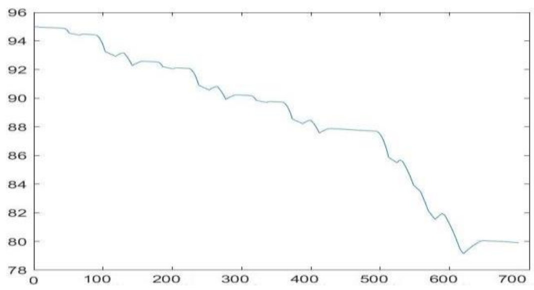

Figure 8: SoC-battery(NEDC cycle)

We note that EMS behaves just like the desired constraints. When we compare the UDDS and NEDC cycles, we find that the car consumes more power in the UDDS cycle. However, the UDDS cycle has more charge points than the NEDC cycle, and a comparison of the cycles reveals that the UDDS cycle is the most realistic (See Figure 9 and 10). The power graph is just as critical as the trajectory of a car. As a result, we see that the left figure shows an overlay of two very tight curves, while the correct figure shows only one curve (the overlay of two curves).

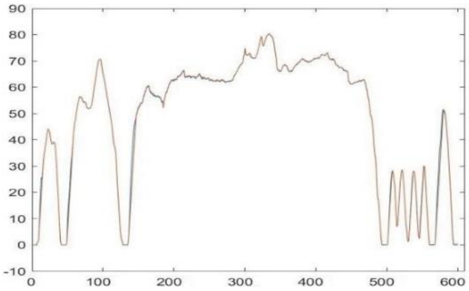

Figure 9 : EV Cycle (UDDS cycle**)**

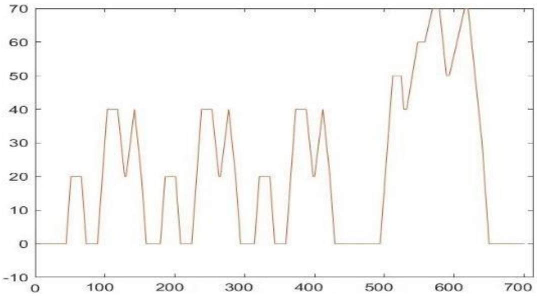

Figure 10: EV Cycle (NEDS cycle)

5. DISCUSSIONS

The proposed EMS is shown by simulating a given driving cycle. However, actual driving conditions are complex and varied; For example, traffic congestion on highways, in cities, in the suburbs and urban areas. In addition, leadership behaviors (for example, leadership styles) are an essential component of the leadership cycle. Diverse drivers may react differently to the same situation, resulting in uncertainty during driving cycles. The optimal performance is highly dependent on the driving cycle, and it is challenging to adapt an existing EMS to a variety of driving conditions. An adaptive EMS was to be developed in the future as a promising solution for our EV model**.**

6. CONCLUSION

EMS for electric vehicles has been extensively examined and compared. EMS strives to reduce the world's fuel use. While it cannot be implemented directly in an actual vehicle, it serves as a benchmark for alternative energy management measures and updated online EMS development. EMS is straightforward to implement in a real car due to the more negligible computational overhead and the absence of prior knowledge of the entire driving cycle while offering similar performance (e.g., fuel economy) as an offline EMS. An Environmental Management System built on instant improvement is a promising approach to balancing real-time execution and fuel economy. In this paper a battery-electric vehicle model is developed, which contains an electric motor, drivetrain, and EM with a storage battery. We extend the primary EM method, which depends on the state of charge and acceleration of the battery. The difference in energy use between the UDDS and NEDS cycle simulations indicates that the more complex the cycle, the higher the power consumption. MATLAB/Simulink simulation results confirmed our results. This effort aims to enhance the model with fuel cell storage through experimental validation.

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