An Exploratory Research on Electric Vehicle Sustainability: An Approach of ADAS

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Abstract

In the 21st century, the automotive industry is witnessing a significant shift as it transitions from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs). This transformative wave, fueled by increasing environmental concerns and advances in technology, calls for an in-depth analysis of the potential nexus for sustainability. This paper explores how the integration of Advanced Driver Assistance Systems (ADAS) in electric vehicles (EVs) has the prospects to meet sustainability. We have followed the exploratory research and secondary literature review based on selected indicators that will make a nexus and ensure to meet the EVs sustainability. We have found key challenges and new possibilities of both electric vehicles and ADAS that need to address while the reconciliation of electric vehicle and ADAS go on which can impact potentially on different dimensions and aspects of the sustainability of electric vehicle. By Analyzing the analytical framework of ADAS in EVs, this paper also aims to give insights into the possibilities and limitations of increasing EVs' sustainability, including overall sustainability and the environmental benefits caused by EVs. In light of these findings, we recommend strategic modifications to state-of-the-art technologies and key indicators to maximize sustainability outcomes. It sets the stage for further exploration of how the synergy of EVs and ADAS can enhance transportation sustainability, thus playing a crucial role in our transition toward a more sustainable future.

Keywords
Electric Vehicles, ADAS, Sustainability, Analytical Framework, Technology Advances.

1. Introduction
Over the last few years, we have been observing the significant growth of electric vehicles (EV) in the automobile industry and has an enormous impact on economic and environmental consumerism. Since the second decade of the 21st century, electric vehicles have become popular and become a unique solution for environmental concerns and sustainable transport. As the environmental issue has become a major concern across the world, Electric vehicle has come up with a vital solution. Electric vehicles can reduce greenhouse emissions and human dependency on fossil fuels. Consequently, the trend of electric vehicles has introduced a new field of research focusing on the sustainability of electric vehicles to ensure the viability of this transformative approach.

In this paper, we have made an insightful literature review to explore the in details of electric vehicle sustainability where all the indicators of ADAS would play a vital role to meet sustainability.
We already found there are many aspects and indicators which are taking the step to ameliorate the global electric vehicles in ADAS. These socio-environment and economic aspects and its concern are increasing day by day.

1.1 Early History and Evolution of Electric Vehicles

In 1828, a Hungarian physicist Ányos Jedlik designed an electric motor to power that model car (Bellis 2019). In 30's decade of the 19th century, Scottish scientist Robert Anderson invented a crude electric-powered carriage (Bobby 2014).
Concurrently, a model vehicle was designed by Professor Stratingh and was brought to fruition by his assistant, Christopher Becker (The world's first electric car, 2021). That year, Thomas Davenport developed a small electric car.

After Karl Benz invented the first patented automobile in 1886, American chemist William Morrison invented an electric carriage in 1888, patenting it in 1890. It could run 14 mph and needed to be recharged every 50 miles. In 1889, Thomas Alva Edison, using a nickel alkaline battery, built a three-wheeled electric vehicle (Valsera-Naranjo et. al 2009). But he kept that aside. By 1912, electric cars became popular in the USA. At that period, steam was the energy source for 40 percent of automobiles, while 38 percent used electricity, leaving a mere 22 percent running on gasoline. In the early 1900s, due to the lack of efficiency of gasoline, electric vehicles were popular (Dang et. al 2014). However, by the 1920s, as gasoline engines became more efficient and affordable, spearheaded by Ford's innovations, EVs were sidelined (Yap 2023).

The late 20th century saw a renewed enthusiasm for EVs, signified by Toyota's introduction of the Prius in Japan in 1997 and its worldwide launch in 2000 (History of the electric car 2021). From figure 1 we can see, Tesla set the pace with groundbreaking models like the Roadster and Model S, prompting other automotive giants to follow suit. Nissan made its mark with the launch of the Leaf in 2010 (Nissan Leaf 2023). By 2022, a significant shift was evident as global EV sales hit 10 million, marking an impressive 60% growth from the previous year and accounting for 14% of total car sales (Demand for electric cars is booming, with sales expected to leap 35% this year after a record-breaking 2022, 2023). China dominated this market, while Europe experienced a 70% surge in 2021's EV sales (Paoli and Gül 2022). Policy directives are accelerating this transition. By 2035, the European Union aims for all new cars to be emission-free (Hernandez 2023), while the US forecasts that electric vehicles will represent half of all new sales (Romaine 2021). According to Global EV Outlook 2023,, China had 13.8 million EVs, Europe boasted 9.3 million, and the USA reported 3 million on their streets (Global EV Outlook 2023: Catching up with climate ambitions 2023).

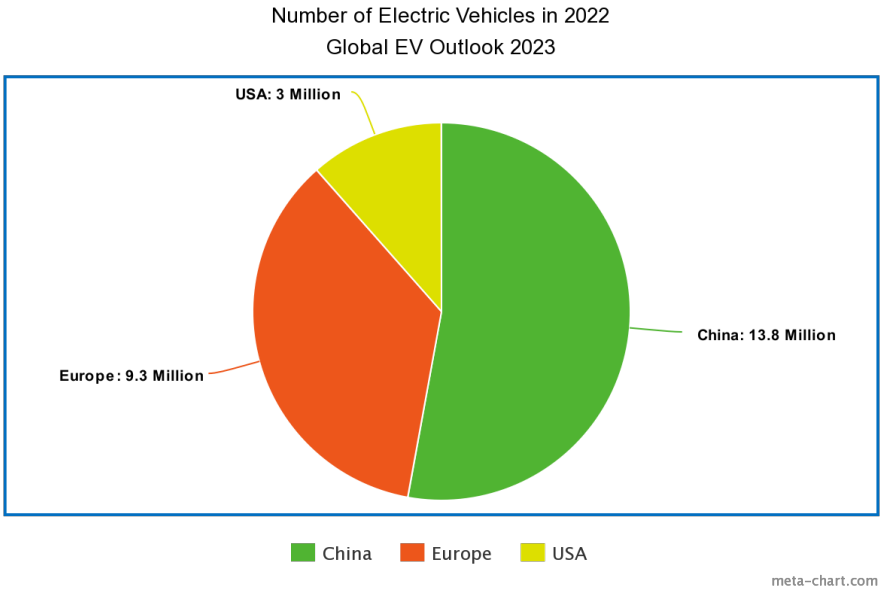

Figure 1. Number of Electric Vehicles in 2022, Global Vehicle Outlook 2023

2. Electric Vehicle Sustainability

Electric vehicle sustainability is a vital aspect of the ongoing transition to environment-friendly transportation and with more sustainability. This section gives an outline of electric vehicle sustainability, focusing on the necessity of electric vehicles, key factors, and environmental benefits. It also explains how the integration of Advanced Driver

Assistance Systems (ADAS) can further increase electric vehicle sustainability. Electric vehicles can be the best alternative to traditional IC engine vehicles. It can play a remarkable road in sustainable progress in the global transportation sector. Reducing greenhouse gas is one of the ways it can significantly contribute to the sustainability of electric vehicles (Jungmeier et al. 2013). Since the introduction of Electric vehicles in the world, it's trying to put a remarkable example of a sustainable transportation solution. Transportation has a significant impact on the environment and life of human beings. The transportation sector, being one of the major contributors to carbon pollution, accounts for approximately 60% of overall emissions. But the rapid growing popularity of electric vehicles can be helpful to reduce a major amount of carbon pollution and improve the environment (Tintelecan et al. 2019). This results in a drive toward a sustainable future.

Electric vehicles integrated with Advanced Driver Assistance Systems (ADAS) can play an important role in increasing the sustainability of the electric vehicle itself. This trending technology can help reduce road accidents, reduce energy consumption, lower fuel consumption, and increase vehicle efficiency (How can ADAS systems reduce fuel consumption and emissions? 2023). Apart from these, ADAS can help the environment and economy as well.

2.1 Life-cycle analysis of electric vehicle

Figure 2 illustrates the Life Cycle Assessment (LCA) is a way that is used to evaluate the environmental effects of a product or system throughout its whole lifetime, with a focus on sustainability (Tintelecan et al. 2019). It includes production, operation, and dismantling. Jungmeier et al. (2013) provided a figure in Figure 2 where three vehicles A, B, and C are shown. During the phase of production, Vehicle A has lower environmental effects but has higher environmental effects in the operation phase, compared to Vehicle B. But Vehicle B has lower overall impacts if we examine the cumulative environmental effects over the entire lifecycle. This is due to the lower effects during the operating and end-of-life phase as they compensate for the production phase of Vehicle B. Vehicle C has the highest environmental effect in the phase of production.

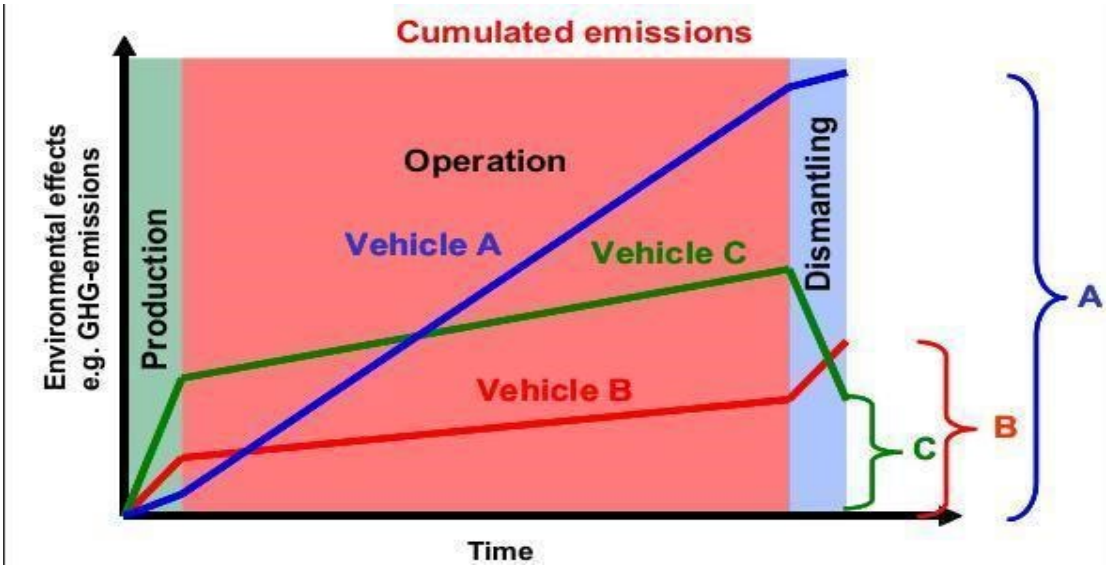

Figure 2. LCA of 3 vehicles of their lifetime based on production, operation, and dismantling steps. (Jungmeier et. al 2013)

2.2 Key challenges in the sustainability of electric vehicle

Despite the rapidly growing popularity and sales of electric vehicles, electric vehicle industries are still facing several challenges. For the long-term sustainability of electric vehicles, these challenges need to be considered to solve. Below, there are some major key challenges that electric vehicle industries are facing now (10 Biggest Challenges Facing the EV Industry Today 2023)

Range Anxiety

Range anxiety is one of the biggest concerns now. As the charging station and charging infrastructures are not sufficient now as traditional gas stations, while driving a long route, people always are concerned about the electric vehicle about how far it can go on one single charge. This concern rises more during the cold or winter season because of the reduction of the battery range of electric vehicles if the temperature goes down below freezing temperature. Most of electric vehicles, in a single charge, can go between a range of 60 to 120 miles. Some luxury models of electric vehicles can go up to 300 miles in one charge. While ICE vehicle's average range in full tank gas is above 300 miles (The top pros and cons of electric cars 2023).

Charging Infrastructure

As the number of charging stations is still not so high, range anxiety is still increasing. However, to solve this issue, the Federal Government is working under Infrastructure Investment and Jobs Act in 2021 and is giving 7.5 billion USD in funding to set up new electric vehicle charging stations across the US. Many electric vehicle owners charge their electric vehicles at their homes, but for those who are living in shared houses, it may become problematic to charge the vehicle at home. As a result, the only solution for them is to charge their vehicle at a charging station. In the UK, as of late 2022 the number of charging hubs was more than 57,000. It's gradually increasing (Tallodi 2022).

Limited Selection

Compared to traditional IC engine vehicles, the variation of electric vehicle models is still not remarkable. Only Tesla is the company that manufactures fully electric vehicles. Other companies are gradually moving ahead to produce fully electric vehicles. Many companies are unveiling the electric version of their IC engine vehicles.

Price

The price of electric vehicles is still very high as they are expensive to make. Though many companies are introducing attractive offers and Governments are giving incentives to make electric vehicles popular, still, due to the availability of cheaper IC engine vehicles, people are interested in buying IC engine vehicles. To tackle this situation, Government incentives should be increased more, and some trade-in offers can be given by the car manufacturers and sellers (The top pros and cons of electric cars 2023).

Technician Crisis

As Electric Vehicle is comparatively a new trend and the industry is still comparatively small, it's difficult to find expert technician and service center for repairing and servicing the electric vehicle. Without expert skills in this field, it's not recommended to work on repairing electric vehicles. In, UK, less than 5% of total mechanics have the skills or qualifications to work on an electric vehicle. The number of mechanics for electric vehicles should increase. Proper training needs to be given to them (Haddad 2021).

Charging Time

From figure 3 we can see the charging time and its challenges. Another challenge of electric vehicles is it takes a lot of time to charge, while gasoline engine cars take only a few moments to fill the oil tank. Normally there are three levels of electric vehicle chargers. Those are Level 1, Level 2, and Level 3. All these 3 level chargers are of different voltages. Among these three, only Level 2 chargers can give full charge in an electric vehicle. But it takes around 3-4 hours and sometimes even 10-12 hours. There are some fast-charging stations, but they take time around 30-60 minutes to charge the battery of an electric vehicle. But it can't give full charge. It can charge the battery up to 80 percent in 30-60 minutes time. Level 1 chargers are used in residence, and it takes 20 hours or more than that to fully charge an electric vehicle (10 Biggest Challenges Facing the EV Industry Today 2023).

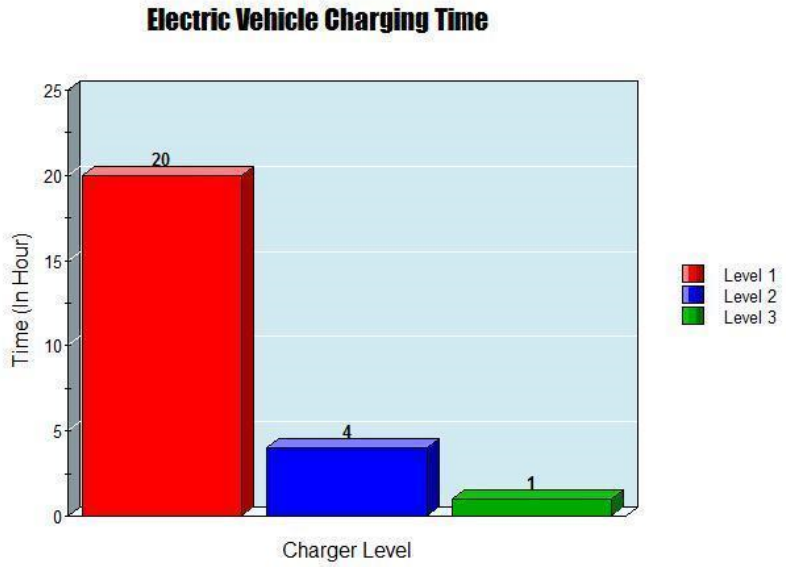

Figure 3. Electrical Vehicle charging time

Grid Capacity
To charge electric vehicles, people will have to rely on electric grids. As a result, grids will have more strains. Grid capacity needs to be improved to avoid the strain. Moreover, charging an electric vehicle, the charger will simultaneously be connected to the grid, and it will affect the power quality. More renewable sources can be the solution to this issue (Ahmed and Karmaker 2019).

Battery Elements
Right now, most of the batteries used in electric vehicles are made of lead-acid. This lead-acid combination can be harmful to the environment and human health. Lead, a heavy metal, and the battery's corrosive acid can both be seriously risky. Exposure to lead can interfere with normal brain function and it can lead to abnormalities in the central nervous system which may cause behavioral and neurological disorders (Dang et al. 2014).

2.3 Why People Are Accepting Electric Vehicles?

Despite Electric Vehicles having some challenges, they have many advantages. There are many reasons why people are accepting electric vehicles nowadays more. Some reasons are explained below.

Effect of EVs on the Environment
Electric vehicles produce zero tailpipe emissions which can contribute to reducing air pollution. Also, Greenhouse gas emission reduction is done by electric vehicles too.

Low Cost
Electric vehicles have fewer moving parts in the engine than ICE vehicles. As a result, the maintenance cost is comparatively cheaper. Moreover, the price of charging an electric vehicle battery is cheaper than the price of diesel. It can save money on fuel.

Energy Efficiency
Unlike conventional vehicles with internal combustion engines that consume fuel while idling, electric vehicles do not use energy when the vehicle is not running, contributing to their superior energy efficiency.

Better Performance
As electric vehicles run on electric motors, it can produce instant torque. As a result, electric vehicles provide better performance. Many electric vehicles can accelerate from 0 to 60 miles per hour in a shorter time than the time ICE vehicles take.

Government Incentives

N V (2019) said that, in 2030, it's predicted that among the new vehicle sales, the range of the share of the total number of electric vehicle sales could be within 40 to 50 percent. The highest adaptation of electric vehicle will be in dense cities, new strict emission regulations will be introduced too.

Governments of several countries of the world are now offering incentives both financial and non-financial to the people to make electric vehicles popular. Among the incentives, tax credits, and emission test exemptions are two of them.

After Joe Biden becomes the President of the United States, to increase the adaptation of electric vehicles, two bills were introduced by the White House. According to the latest information, Federal Tax Credit will remain at $7500. The credit begins to phase out for a manufacturer's electric vehicles when 200,000 vehicles have been sold in the U.S. For example, Tesla and General Motors have already reached this threshold, so their vehicles are no longer eligible for the federal tax credit. To get the Federal Tax Credit for electric vehicles in the USA, the vehicle must be assembled in the USA and the entire tax credit of $7,500 is split into two equal parts, each part has its own qualifying criteria. A vehicle is either eligible for each part of the credit or it isn't. One part of the credit, amounting to $3,750, requires that at least 40% of the vehicle's battery essential minerals come from the United States or from countries that have a free trade agreement with the United States. The remaining $3,750 of the credit depends on whether at least 50% of the vehicle's battery components originate from the United States or from countries that have a free trade agreement with the US (Doll 2023).

3 ADAS on Electrical Vehicles

Advanced Driver-Assistance Systems (ADAS) is an emerging technology combined with several electrical technologies. It assists a driver in driving and aims to ensure the safety of the vehicle and passengers and avoid crashes. This technology gradually started gaining popularity in the 2000s (Gancarczyk 2019). Forward Collision Warning, Automatic Emergency Braking, Lane Departure Warning, Adaptive Cruise Control, and Blind Spot Monitoring are some examples of ADAS. From 2000 to 2010, the mostly used ADAS technologies were Blind Spot Detection and Forward Collision Warning. Later, in the last decade, Automatic Emergency Breaking and other ADAS technologies were introduced. Automatic Emergency Brakes can reduce rear-end crashes by 40%. It's expected that, by 2030, more than 50% of vehicles will be equipped with ADAS technologies (Gancarczyk 2019) were introduced. Automatic Emergency Brakes can reduce rear-end crashes by 40%. It's expected that, by 2030, more than 50% of vehicles will be equipped with ADAS technologies (Gancarczyk 2019).

Table 1. Overview of some ADAS Technologies

ADAS Technology	**How it works**
Forward Collision Warning	This technology gives an alert to the driver to make him aware of a front collision. It uses RADAR, Laser, and Cameras while the driver drives. (My Car Does What 2023)
Automatic Emergency Braking	It automatically brakes and stops the vehicle or reduces the speed to avoid or mitigate the collision. This technology can identify possible collision by using camera and sensors. (Wardlaw 2021)
Lane Departure Warning	Lane Departure Warning alerts the driver if the vehicle leaves the lane. It gives a visual, audio alert. It helps to avoid collisions while changing lanes. (My Car Does What 2023)
Adaptive Cruise Control	This technology is an example of Cyber-Physical Systems in the automotive field (Atallah et al. 2017). It is designed to maintain safe distance.
Blind Spot Monitoring	It gives an alert to the vehicle driver in blind spots

	(Barry 2017)
Parking Assist	This technology assists in parking (What is Park Assist? Quick Guide 2023)
Traffic Sign Recognition	This can recognize and detect traffic signs and can give decisions to the driver accordingly. In USA, this technology can detect speed limit sign, do not enter sign. (Understanding ADAS: Traffic Sign Recognition 2021)
Driver Drowsiness Detection	This technology can prevent collision if the driver is found drowsy. (Driver Drowsiness Detection System with OpenCV & Keras 2023)
Rearview Camera	It gives a clear image of the surroundings of the rear side which can help a driver while reversing the car or even can sometimes help reduce rear-end collision (Understanding ADAS: Backup Camera Systems 2021)
Intelligent Headlights	It can adjust the headlights. It is also known as Smart Headlight. (Teague 2021)

3.1 Some Electric Vehicles with ADAS Technologies

Electric Vehicle manufacturers are integrating ADAS technologies to enhance the safety of the vehicle and to increase the sustainability of the electric vehicle. Below given are three electric vehicles equipped with ADAS.

Table 2. Some electric vehicles with ADAS technologies

Vehicle	**ADAS technologies that equipped in the vehicle**
Tesla Model 3	Autopilot, adaptive cruise control, lane-keeping assist, and automatic emergency braking.(Tesla Model 3 2023)
Nissan Leaf	Intelligent cruise control, emergency braking, lane departure warning, Blind Spot Warning, rear cross-traffic alert, (2023 Nissan LEAF Electric Car Safety Features 2023)
BMW i3	Adaptive cruise control, lane departure warning, cross-traffic assist (BMW launches the 2018 i3 and i3s with parking assistance 2017)

4 Analytical Frameworks of Sustainability

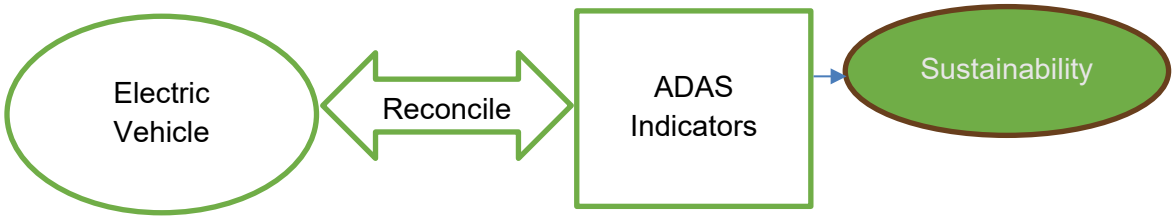

Figure 4. Analytical framework of ADAS on EV towards sustainability

As depicted in Figure 4, achieving sustainability in electric vehicles (EVs) requires a continuous integration of ADAS (Advanced Driver Assistance Systems) indicators. This integrative approach lays the foundation for an analytical framework, ensuring a strike balance between ADAS indicators and EV performance. Our analysis reveals specific ADAS indicators, as outlined in Table 2, that are imperative for ensuring the safety of EVs. Without adequately addressing these indicators, the sustainability of EVs remains questionable. Therefore, when developing and refining EVs, it is essential to prioritize these indicators. Improving upon these parameters is indispensable for any advancements or modifications in the realm of EVs. In conclusion, our findings underscore the importance of implementing ADAS in EVs to ensure their long-term sustainability. In addition, future research should probe into the intricacies of how ADAS indicators can be seamlessly integrated into EV designs to fortify their eco-friendliness and safety.

4.1 ADAS Implementation on Electric Vehicles

As electric vehicles are being considered sustainable transportation, the sustainability of this type of vehicle can be increased with the significant contribution of ADAS. ADAS can contribute to an electric vehicle's safety, accident reduction, energy efficiency, autonomous driving, and so on. Environmental protection, energy saving, and safety are the three major factors of a vehicle in this age (Wang et al. 2011). Interestingly, ADAS can contribute to all of them if integrated into electric vehicles.

Enhancement of Safety

Vehicle manufacturers are giving more emphasis on vehicle safety as manufacturers are considering this as an important factor in maintaining competitiveness **(**Moravčík and Jaśkiewicz 2018). Automatic Emergency Braking, Forward Collision Warning and other ADAS technologies can help prevent death and injuries by reducing accidents and collisions (What is ADAS? 2023). By reducing collisions, ADAS can contribute minimize the consequences of the environment because of the pollutants and hazardous materials coming out of the collided vehicle.

Energy Efficiency and Consumption

Energy consumption in electric vehicles can be optimized by ADAS. ADAS can increase energy efficiency and to some extent, can save energy. For example, if we consider regenerative brakes, ADAS can capture and convert the energy which was supposed to be lost. This captured energy can recharge the battery of the electric vehicle.

Eco-Routing

ADAS is based on GPS technology (ADAS/DMS Technology: intelligent assistance for driving on the highway 2023). Some ADAS technologies have GPS with eco-routing technology. Eco-routing refers to the process of determining the most optimal route for a vehicle to travel between two destinations in terms of energy efficiency. It is proposed as a strategy for drivers to minimize their fuel consumption and, consequently, mitigate the environmental impact of their trips by reducing carbon emissions (Minett et al. 2011). Through Eco-Routing, ADAS can save the battery life of an electric vehicle by reducing unnecessary energy consumption.

Better Experience of Driving

Adaptive Cruise Control, Blind Spot Monitoring, Parking Assist and other ADAS technologies can provide a better and more enjoyable driving experience to drivers. These technologies can help a driver to avoid collisions, to find a better route, to help saving energy etc.,

Data Analysis

Integrating ADAS in electric vehicles can make vehicles understand road conditions, the easiest route, driving patterns, and distances to avoid by collecting data and analyzing them. It can also support electric vehicle tracking, vehicle sharing, and charging station selection with the help of telematics system using wireless communication (N V (2019).

Autonomous Driving

Integrating ADAS in electric vehicles can set a remarkable milestone in Autonomous Driving, where a car will drive automatically fully or partially. ADAS can help an electric vehicle towards Autonomous Driving with ADAS technologies, algorithms, and frameworks. Autonomous Driving can originate from robotics, embedded systems, sensing, and navigation. It helps a vehicle or electric vehicle not only by guiding but it can control the vehicle while stability concern rises. The automotive sector is in a competitive race to develop autonomous vehicles within the next five years. This means that it is anticipated that autonomous cars will be operational on the existing Roadway Transportation System (RTS) between 2020 and 2025.

4.2 Challenges of Integrating ADAS in Electric Vehicles

Both ADAS and Electric Vehicles are growing rapidly. Integrating ADAS in the EVs can help to increase the sustainability of the vehicle as well as ensure the safety of the vehicle and passengers, still, it has some challenges. This section discusses the key challenges of integrating ADAS in Electric Vehicles.

Energy Management: While ADAS works in Electric Vehicles, it consumes power and energy.

Software Complexity

ADAS and Electric Vehicle come up with much software to operate those technologies. This software is complex. Due to the complexity, testing, integrating, and installing this software can be challenging.

Data Processing

ADAS generates and processes so much data in real-time. Managing that data and communicating between the vehicle and the ADAS technologies can become challenging sometimes.

Hardware Integration

ADAS requires many sensors and cameras to work. Sometimes it's difficult and challenging to interfere between ADAS and the system of electric vehicles.

Cybersecurity

As ADAS and Electric vehicles have many concerns about connectivity with each other's technologies, sometimes it can be challenging to ensure safety, which can lead to hacking.

Customers' Adaptability

It's challenging to convince customers to adapt to ADAS technologies. If ADAS technologies are not used correctly, it may lead to safety issues.

To solve and overcome all the challenges above, automotive industries are working and investing to conduct research and development to advance the technologies which can hopefully resolve the challenges of integrating ADAS in Electric Vehicles.

5 Conclusion and Recommendations

We have explored the intersection of electric vehicle (EV) sustainability and the integration of Advanced Driver Assistance Systems (ADAS). Through an exploitative research approach, we have examined the benefits and challenges associated with ADAS technologies in enhancing the sustainability of EVs. The research objectives of this study were to investigate the importance of integrating ADAS technologies in EVs, understand the social and environmental effects, analyze the economic impacts, and examine the current trends in EVs. We have fulfilled these objectives and provided valuable insights by explorative analysis. Our findings highlight that ADAS technologies contribute to enhanced safety by reducing accidents and mitigating their severity. They also optimize energy consumption. Furthermore, ADAS in EVs has positive economic impacts, including reduced maintenance costs and increased driver convenience. We can say, by integrating ADAS in electric vehicles, in future, electric vehicles will be safer, more efficient, and environmentally friendly.

Reference

10 Biggest Challenges Facing the EV Industry Today, Available: https://evchargingsummit.com/blog/challenges-facing-the-ev-industry-today/ , Accessed on July 29, 2023.

ADAS/DMS Technology: intelligent assistance for driving on the highway, Available: https://www.redgps.com/en/solutions/ontracking/adas-dms-technology#:~:text=The%20ADAS%2FDMS%20system%20is,%2C%20sensors%2C%20and%20status%20monitors, Accessed on July 10, 2023.

Ahmed, M.R., and Karmaker, A.K., Challenges for Electric Vehicle Adoption in Bangladesh, *Proceedings of 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE)*, pp. 1-6, Cox'sBazar, Bangladesh, 2019, doi: 10.1109/ECACE.2019.8679288.

Atallah, A., Bany Hamad, G., and Ait Mohamed, O., "Automotive safety verification under temporal failure of adaptive cruise control system using statistical model checking," *Proceedings of 2017 First International Conference on Embedded & Distributed Systems (EDiS)*, pp. 1-6, Oran, Algeria, 2017, doi: 10.1109/EDIS.2017.8284024.

Bellis, M. , The History of Electric Vehicles Began in 1930, Available: https://www.thoughtco.com/history-of-electric-vehicles-1991603 , July 31, 2023.

BMW launches the 2018 i3 and i3s with parking assistance, Available: https://safecarnews.com/staging/bmw-launches-the-2018-i3-and-i3s-with-parking-assistance/. Accessed on Jul. 12, 2023.

Bobby, Robert Anderson (19th Century Scottish Inventor), Available: https://www.upsbatterycenter.com/blog/robert-anderson-19th-century-scottish-inventor/ , July 9, 2023.

Chris Teague, Here's How Smart Headlights Work, Available: https://www.autoweek.com/news/technology/a36031601/heres-how-smart-headlights-work/, Jul. 12, 2023.

Christian Wardlaw, What is Automatic Emergency Braking?, Available: https://www.jdpower.com/cars/shopping-guides/what-is-automatic-emergency-braking, Jul. 12, 2023.

Dang, S., Odonde, A., Mirza, T., Dissanayake, C., and Burns, R., "Sustainable energy management: An analysis report of the impacts of Electric Vehicles," *Proceedings of 2014 14th International Conference on Environment and Electrical Engineering*, pp. 318-322, Krakow, Poland, 2014, doi: 10.1109/EEEIC.2014.6835886.

Demand for electric cars is booming, with sales expected to leap 35% this year after a record-breaking 2022, Available: https://www.iea.org/news/demand-for-electric-cars-is-booming-with-sales-expected-to-leap-35-this-year-after-a-record-breaking-2022 , Accessed on July 29, 2023.

Doll, S., Which electric vehicles still qualify for us federal tax credit, Available: https://electrek.co/2023/06/07/which-electric-vehicles-still-qualify-for-us-federal-tax-credit/ , July 10, 2023.

Driver Drowsiness Detection System with OpenCV & Keras, Available: https://data-flair.training/blogs/python-project-driver-drowsiness-detection-system/. Accessed on Jul. 12, 2023.

Gancarczyk, S., How Will Advanced Driver Assistance Systems Impact Collision Rates in the Future? Available: https://www.iaai.com/articles/how-will-advanced-driver-assistance-systems-impact-collision-rates-in-the-future , July 10, 2023.

Global EV Outlook 2023: Catching up with climate ambitions, Available: https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf, Accessed on Jul. 12, 2023.

History of the electric car, Available: https://blog.evbox.com/electric-cars-history , Accessed on July 29, 2023.

How can ADAS systems reduce fuel consumption and emissions? Available: https://www.linkedin.com/advice/1/how-can-adas-systems-reduce-fuel-consumption. Accessed on Jul. 12, 2023.

Jenna Romaine, All new US vehicles could be required to be electric by 2035, new study says, Available: https://thehill.com/changing-america/sustainability/energy/548394-all-new-us-vehicles-could-be-required-to-be-electric. Accessed on Jul. 12, 2023.

Joe Hernandez, All new cars in the EU will be zero-emission by 2035. Here's where the U.S. stands, Available: https://www.npr.org/2023/03/30/1166921698/eu-zero-emission-cars. Accessed on July 12, 2023.

John Tallodi, Seven disadvantages of electric cars. Available: https://www.carwow.co.uk/guides/choosing/disadvantages-of-electric-cars#gref, Jul. 12, 2023.

Jungmeier, G., Dunn, J.B., Elgowainy, A., Özdemir, E.D., Ehrenberger, S., Althaus, H.J., and Widmer, R., Key issues in life cycle assessment of electric vehicles — Findings in the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV), *Proceedings of 2013 World Electric Vehicle Symposium and Exhibition (EVS27)*, pp. 1-7, Barcelona, Spain, 2013, doi: 10.1109/EVS.2013.6914862.

Jungmeier, G., Dunn, J., Elgowainy, A., Gaines, L., Ehrenberger, S., Özdemir, E. D., Althaus, and H-J., Widmer, R.. "Life cycle assessment of electric vehicles – Key issues of Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV)". *Proceedings of 2013 World Electric Vehicle Symposium and Exhibition, EVS*, Barcelona, Spain, 2013 doi:. 10.1109/EVS.2013.6914862.

Keith Barry, Guide to Blind Spot Warning, Available: https://www.consumerreports.org/cars/car-safety/guide-to-blind-spot-warning-a1263069503/. Accessed on Jul. 12, 2023.

Leonardo Paoli and Timur Gül, Electric cars fend off supply challenges to more than double global sales, Available: https://www.iea.org/commentaries/electric-cars-fend-off-supply-challenges-to-more-than-double-global-sales. Accessed on July 12, 2023.

Minett, C. F., Salomons, A. M., Daamen, W., van Arem, B., and Kuijpers, S., Eco-routing: Comparing the fuel consumption of different routes between an origin and destination using field test speed profiles and synthetic speed profiles, *Proceedings of 2011 IEEE Forum on Integrated and Sustainable Transportation Systems*, pp. 32-39, Vienna, Austria, 2011, doi: 10.1109/FISTS.2011.5973621.

Moravčík, Ľ., and Jaśkiewicz, M., Boosting car safety in the EU, *Proceedings of 2018 XI International Science-Technical Conference Automotive Safety*, pp. 1-5, Žastá, Slovakia, 2018, doi: 10.1109/AUTOSAFE.2018.8373307.

My Car Does What, Available: https://mycardoeswhat.org/deeper-learning/forward-collision-warning/. Accessed on Jul. 13, 2023.

N V, J., Driving the future - electric mobility a paradigm shift & its challenges, *Proceedings of 2019 IEEE Transportation Electrification Conference (ITEC-India)*, pp. 1-4, Bengaluru, India, 2019, doi: 10.1109/ITEC-India48457.2019.ITECINDIA2019-146.

Nissan Leaf, Available: https://en.wikipedia.org/wiki/Nissan_Leaf, Accessed on July 12, 2023.2023

Nissan LEAF Electric Car Safety Features, Available: https://www.nissanusa.com/vehicles/electric-cars/leaf/features/safety-features.html. Accessed on Jul. 12, 2023.

Sam Haddad, Are mechanics ready for electric vehicles? Available: https://www.raconteur.net/transport/are-mechanics-ready-for-electric-vehicles/, Jul. 12, 2023.

Tesla Model 3, Available: https://en.wikipedia.org/wiki/Tesla_Model_3 Accessed on Jul. 12, 2013.

The top pros and cons of electric cars, Available: https://www.energysage.com/electric-vehicles/101/pros-and-cons-electric-cars/#:~:text=Some%20disadvantages%20to%20buying%20electric,stations%2C%20and%20higher%20initial%20costs. Accessed on Jul. 12, 2023.

The world's first electric car, Available: https://www.rug.nl/museum/collections/collection-stories/wagentje-van-stratingh, July 31, 2023.

Tintelecan, A., Constantinescu - Dobra, A., and Marțiș, C., LCA Indicators in Electric Vehicles Environmental Impact Assessment, *Proceedings of 2019 Electric Vehicles International Conference (EV)*, pp. 1-5, Bucharest, Romania, 2019, doi: 10.1109/EV.2019.8892893.

Understanding ADAS: Backup Camera Systems, Available: https://caradas.com/backup-camera/. Accessed on Jul. 12, 2023.

Understanding ADAS: Traffic Sign Recognition, Available: https://caradas.com/understanding-adas-traffic-sign-recognition/. Accessed on Jul. 12, 2023.

Valsera-Naranjo, E., Sumper, A., Lloret-Gallego, P., Villafáfila-Robles, R., and Sudria-Andreu, A., Electrical vehicles: State of art and issues for their connection to the network, *Proceedings of 2009 10th International Conference on Electrical Power Quality and Utilisation*, pp. 1-3, Lodz, Poland, 2009, doi: 10.1109/EPQU.2009.5318813.

Wang, Z., Shi, S., and Liu, P., Research Progress on Collision Safety of Electric Vehicles, *Proceedings of 2011 Third International Conference on Measuring Technology and Mechatronics Automation*, pp. 153-156, Shanghai, China, 2011, doi: 10.1109/ICMTMA.2011.610.

What is ADAS?, Available: https://www.synopsys.com/automotive/what-is-adas.html. Accessed on Jul. 12, 2023.

What is Park Assist? Quick Guide, Available: https://www.caranddriver.com/research/a32814141/park-assist/. Accessed on Jul. 12, 2023.

Yap, L., History of Early Electric Cars, Available: https://www.greencars.com/greencars-101/history-of-early-electric cars?utm_source=google&utm_medium=cpc&utm_campaign=dynamic_blogs_combined&utm_term=&gclid=CjwKCAjw-b-kBhB EiwA4fvKrIGhFGDQAyAc4ICUctEu0Ct8sxcBPmwA97Zm2PPCBkU75NcPNnU6whoC0woQAvD_BwE, July 29, 2023.

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