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Advancements in Battery Technology for Electric Vehicles: A Comprehensive Analysis of Recent Developments

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Abstract

Numerous recent innovations have been attained with the objective of bettering electric vehicles and their components, especially in the domains of energy management, battery design and optimization, and autonomous driving. As a result, the eco-system becomes more efficient and long-lasting, and the technology for electric cars of the future is advanced. Insights into cutting-edge e-mobility research and developments, including electric cars (EVs) and other novel, inventive, and promising technologies, are provided by this study. These developments may be feasible by 2030. Digital twins that are linked to the Internet in Things (Iota) are one example of an appropriate modelling and design strategy covered in this research. Thanks to the concept of the Internet of Things, autonomous vehicles could improve road safety, fuel efficiency, and supply drivers more time for other tasks. Additionally discussed in this article is the technology that allows a vehicle to leave a parking spot, drive along a lengthy roadway, and finally park at its destination. The information gathered for use on real roads is crucial to the advancement of autonomous vehicles. Proposals for intelligent, autonomous vehicles and research needs are also present. The description includes numerous societal problems, one of which is the reason of an accident involving an autonomous car. We quickly go over a smart gadget that can detect unusual driving habits and stop accidents in their tracks. Additionally, every area of study pertaining to electric vehicles is addressed, along with the anticipated difficulties and gaps in understanding in each. This includes areas such as environmental evaluation, market research, power electronics, powertrain engineering, and power battery material sciences.

Keywords: *Electrical Vehicles; AVs that drive themselves; EV parts; e-mobility*

1. Introduction

Although the charging infrastructures are still seen as a big issue. As shown in [10], there has been a tremendous explosion of renewable energy sources in the power grid, and the electric cars are undeniably eco-friendly [8, 9]. In addition to highlighting the most recent state-of-the-art developments in this area of e-mobility, this review paper will endeavour to delve further into these concerns [11–13]. By 2020, the specific energy of the battery might have jumped from about 110 Wh/kg to 275 Wh/kg. As a result, this development suggests that it might achieve 450 Wh/kg by 2030. Moreover, the electricity density likewise rose from 300 Wh/L - 560 Wh/L from 2009 to 2021 (in only 10 years). It follows that it might go up to 1,100 Wh/L in 2030. There is a decrease in the cost when it comes to batteries. The price of batteries, which was formerly 1200 EUR/kWh, has dropped to 120 EUR/kWh and is expected to drop to 50 EUR/kWh soon. Therefore, this review article also includes the present status of battery

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technology [11–13]. If we go further into the topic of traction inverter the amount of power, we find that it has climbed to 35 kW/L and is projected to reach 60 kW/L in the next decade [11]. Incorporating broad band gap methods, researchers have increased efficiency to 98% while increasing range of driving by 8%. The extent to which electric vehicles contribute to environmental sustainability is most affected by the power generation technology. According to the European Energy Mix, CO_2 emissions of 2010 were 300 g/kWh. By implementing renewable energy sources and possibly decommissioning nuclear power facilities, CO_2 emissions might be brought down to 200 g/kWh by 2030, if not lower. Considering the ingesting and outputs of the electric cars used for electrical power, the CO_2 emissions per automobile will drop form 66 g/km in 2010 to less than 30 g/km in 2030 [11–14]. People expect to start using AVs (autonomous vehicles) by the year 2030. Electric and shared, they are likely to be. In 2010, the SAE brought attention to the fact that several pre-owned commercial vehicles have been outfitted with level 1 automation. Some of the most recent state-of-the-art vehicle technologies even have level 4 automation, and the others have already reached level 3. You can use them for novel services for mobility right now because they have AI features built into modern communication networks. Additionally, this article contains such development. In the modern day, the Internet of devices allows for the sensing, processing, and actuation of thousands of devices. In addition to facilitating quick data sharing, this will also allow for smooth cooperation [14–16]. Automobile mobility, automation, and smart city applications all make use of such platforms. Not only can these platforms detect dangers, but they can also eliminate them [14–20]. One may observe that drivers are required to execute a number of tasks while on the road, including adjusting the accelerator and brake pedals, paying attention to road signs, and changing lanes and indicators as needed [21]. To function, an autonomous vehicle needs to take its environment into account [22]. This is accomplished through the five fundamental processes: perception, planning, localization, the steering wheel controls system, and system administration. The localization module is in charge of making location estimates, while the impression module constructs a model of what is happening while driving using data from many sensors. So far, as far as the planning module is concerned, it is primarily responsible for making decisions on the EV's manoeuvrability based on safer mapping and localization. All of this is feasible only based on the perceptual data. In addition, the vehicle's control system regulates the accelerator, steering, and braking systems. Consequently, the process becomes quite involved due to the need to consider all road elements, including pedestrians, cyclists, other cars, etc. A crucial component of autonomous electric vehicles, communication methods module enables the vehicle to handle such tasks while being driven on roadways. A common term for this kind of interaction is "vehicle-to-everything" (V2X) communication,

which includes "vehicle-to-vehicle," "vehicle-to-infrastructure," "vehicle-to-pedestrian," and "vehicle-to-network" (V2N) communication, among others [24, 25]. So far, research has shown that two vehicles may talk with each other, a phenomenon called vehicle-to-vehicle communication [25, 26]. By making other vehicles on the road aware of each other, this allows for a decrease in collisions and the ability to leave the road at a normal speed and acceleration [27]. Alternatively, vehicle-to-infrastructure (V2I) communication enables the vehicle to establish a connection with roadside infrastructure, thereby disseminating data extensively [28]. All the necessary data on safe distances from other vehicles, speed limits, safety, obstacles and accidental warnings may be found among the sophisticated services; it also aids with lane tracking [29]. The concept of "V2P"—vehicle-to-pedestrian information interchanges using sensors and cognitive technology—is central to the goal of accident reduction [30–32]. V2N links the equipment used by drivers to a server that provides centralized control and data about roads, traffic, and services [33]. The use of V2X communications along with pre-existing vehicle-sensing capabilities forms the backbone of intricate applications that aim to improve traffic flow, passenger entertainment, factory services, and road safety [34, 35]. Ultimately, data collected from actual touch is what these algorithms need to succeed when applied in a real-life context [36]. To monitor the rear vehicles, for example, machine vision employs image processing [37] and trajectories of the drivers in a given jurisdiction [38]. Additionally, by analysing past data, the optimal control parameters can be identified, which in turn maximize fuel efficiency and save fuel [39]. Utilizing data obtained from in-car sensors to analyses driver behaviour, regardless of being the transport is not completely autonomous, reduces the likelihood of intoxicated or drowsy driving [40]. Research on vehicle-to-extensive X-communication has focused on network security and connectivity [41–45]. Different parts of the autonomous car have also been the subject of reviews. Beginning with the challenges, uses, and needs for vehicle data, Siegel as well as others [40] laid out the current state of the skill for linked vehicles. Half of the issues can be resolved through

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cooperative traffic management and communication amongst transportation infrastructures, as stated in [46]. While they do cover methods for signalized intersections, their study is primarily concerned with non-signalized junctions. In [47], the comprehensive analysis of autonomous overtaking was published. Two essential elements of high-speed overtaking, as shown by the authors, are an accurate knowledge of the surrounding environment and any adjacent obstacles, and the dynamics of the vehicles involved. In their evaluation of localization approaches, Bresson et al. [48] considered autonomous vehicles that have sensor-based systems integrated into their bodies and a communication network (V2V, V2I, or both).

1.1 Cloud-Based Transportation Network Research:

In addition, cloud computing has been the subject of other scientific contributions [49–58]. Published in peer-reviewed academic journals, these studies examine cloud-based vehicular computing and its potential extensions to mobile cloud computing and transport systems. Cloud apps, their development, and the communication system architecture are only a few examples of the other areas of privacy and security-related subjects that might be found here. There was discussion of the challenges of vehicle network of clouds in [50, 51]. In a more fluid context, one can find comparable conversations about vehicular cloud alternatives, such as traffic scenarios, services, and apps [52, 53]. This review is one of several that have focused on a given subject. Network connectivity was the main emphasis of the paper [40], which covered a broader subject. There weren't many specifics in the application. However, as an example if driver monitoring, the scientist in [40] solely mentioned programmers that might use data gathered to check drivers, thus reducing the danger to sluggish drinking. Although we have searched the literature extensively, we have not been able to locate any research on the most recent developments in autonomous vehicle technology. The purpose of including this in our investigation article is to provide an opinion on whether or not the aforementioned tasks will be carried out by current autonomous vehicle technology. Improving reduced emissions and usage of energy without compromising the vehicle's performance is achieved through the use of fuzzy logic, advanced predictive control, and other techniques. To enhance the vehicle's output characteristics, the EMS is used, and some of these detail its immediate fashion development process and calibration settings. Among these factors are state-of-charge, speed, power-split, and others. Investigating a thorough method for developing the control infrastructure of an EMS employing numerous control techniques is the main objective of this sort of research. Suitably emphasized are the limitations and challenges associated with EMS advances, as well as a short proposal and discussion on how future EMS research might be improved. Finally, an interpretative study [39] uncovered the relevance and possible consequences of real-time the EMSs with various control systems. These solutions are proposed for future transportation that is expected to be sustainable according to of energy the next, consumption, and vehicle emissions. Embedded intelligent systems are crucial to the electrification, autonomy, and deployment of vehicles. There are a lot of roadblocks that are preventing electric vehicles from being widely used in the automobile industry, even though the technology for electric cars is expected to dominate the engines design in the decades that follow. There are four main types of these challenges: customer behaviour, charging infrastructure, vehicle performance, and government support. Therefore, making sure these challenges are fully understood is important. Studying each obstacle and deducing their relative order of removal is the focus of this essay, which ranks them according to importance [40].

To kick things off, this article explains the digital-twin based vehicle propellant system (DTVPS) and how it uses the latest trend in semiconductor technology—wide band gap (WBG)—in power converters—to achieve revolutionary benefits. Those interested in learning more about fast charger technology as it relates to V2G and V2D communication systems can do so in the future [59,60]. Further, these cutting-edge tactics enhance the capabilities of contemporary autonomous vehicles, and one can see the results of their general inquiry. Additionally, this manuscript includes a suggestion for fixing the problems. Consequently, this research study aims to paint a broad picture of the subject by reviewing the relevant literature, which encompasses related fields but refrains from discussing algorithms just yet.

2. Future Electric Vehicle Propulsion Systems

A power converter, battery, electric motor, and fixed gearbox are the four main components of an electric vehicle's propulsion system, which makes the concept straightforward to understand. In addition, a gearbox is unnecessary, and neither clutch nor oil filters are not required. In addition to enhancing driving comfort, this also reduces costs [61–64]. In this part, you may discover data related to the future of electric vehicle propulsion market trends and also identify new avenues for research.

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2.1 EV Digital Twin Benefits and Development:

Analytical и simulation models of both full EVs and their component elements have been developed by automotive engineers and scientists for a long time. The accuracy and sophistication of these models have grown throughout the years. The rise of sensor technologies and robust Iota-like features has transformed all offline models into digital ones, granting users lifetime access to features like fault endurance and recognition, predictive maintenance, and the freedom to reschedule maintenance. This leads to a decrease in the expenses associated with the manufacturing process's intermediate processes, like validating and verifying the system design. For these reasons, digital twins have been launched using cutting-edge tactics including cloud computing, artificial intelligence, and the internet of things [65, 66]. Figure 1 depicts a complete electric car with all the necessary parts, including a power conversion device, battery, and an appropriate number of sensors connected to a motor. This is to explain the whole concept of a digital twin. In this digital setting, you may find the simulation platform's representational model. A very realistic model has been developed using a multi-physics framework, which facilitates the exchange of data and information across the digital and physical domains. The vehicle's designer has the ability to develop an electronic technique that operates in conjunction with the physical process, providing a valuable tool for assessing the model from both static and dynamic perspectives.

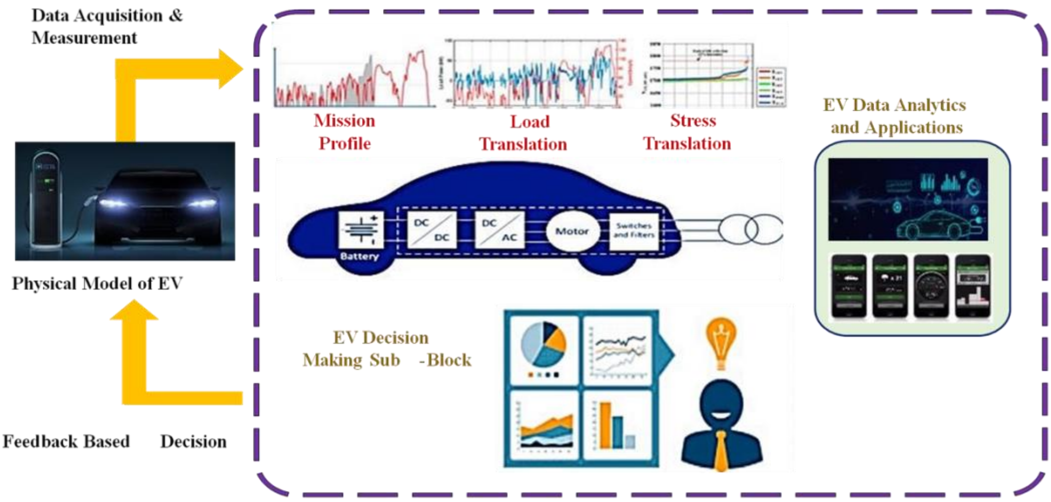

Figure 1. **The building of a virtual counterpart is an operational concept.**

2.2 Electric vehicle digital twin architecture and tool features include:

Achieving substantial improvements in the usability, energy efficiency, and functionality of future EVs: Using these standards, we may evaluate the vehicle's practicality and features, such as its price, mileage, predicted range, total travel time, suitability for long-distance travel, comfort in all weather conditions, and handling of traffic.

2.3 Analysing stress with multi-physics modelling:

Predicting faults in advance, this analysis helps avert failures and reduces downtime. Analysis of dependability using mission profiles for predictive maintenance: The components critical to the reliability of a battery-powered electric vehicle's drivetrain can be detected using mission-profile-oriented expedited lifetime testing. Consequently, engineers working on the product will have a better chance of reliably and rapidly inventing new ideas by trying out different permutations of automotive components and other variables. In addition, by analysing the data received from the cars' digital twins, maintenance protocols and routines can be developed. This helps to reduce inventory stocks by making sure parts are accessible before they are expected to fail in the electric vehicle. Future developments will likely centre on the digital twin's application to control design, powertrain design, and the reliability of novel, cutting-edge powertrains. Its design, digital-twin-based control architecture, and reliability are three important areas that are shared. Improvements in reliability and efficiency in the next generation of vehicles will need work in all of these areas.

2.4 Interfaces for Power Electronics

An essential part of every electric vehicle's powertrain is the power electronic converter [11]. The use of semiconductor-based

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materials as switches in these power converters has been the subject of extensive research. At the moment, these switches are being considered using materials derived from silicon (Si) or the silicon carbide (SiC). As mentioned in [67-70], some of them employ gallium nitride (GaN). The switching frequency is the sole restriction or limitation of such switches. The switching frequency is limited in designs of silicon based IGBT traction inverters, which is a problem when trying to meet user requirements [71]. In order to conduct electricity, these materials with a broad band gap require energy levels of one or two electron volts to move an electron towards the valence region [67-73]. Figure 2 shows these characteristics. The rate at which the switch for on-board chargers (OBCs) based on MOSFETs must be below 100 kHz for OBCs based on Si [72]. In contrast to conventional Si semiconductors, WBGs exhibit remarkable properties and cutting-edge material features such improved thermal conductivity, higher switching frequencies, lower leakage current, and the ability to operate at higher voltages. Consequently, the WBG semiconductor, which is based on high frequencies, offers superior power density and good efficiency for low voltage applications. The electric powertrain becomes more efficient and the converter's overall weight decreases as a result. In addition, operating on high temperature readings is also possible with these high frequencies, which range from 40 kHz to 100 kHz for proactive front-end inverters and up to 200 to 500 kHz for OBC systems. It has been noted that the thermal regulation of GaN-based semiconductor circuits receives significantly less attention. In order to make predictions based on both parametric and non-parametric representations, accurate models of GaN-based electronic power converters are necessary. Furthermore, semiconductor modules are the faultiest components of power electronic converters. Their great thermal stress characteristic is the reason behind this. Dielectric breakdowns, which are influenced by time, are a common cause of these failures [74]. Because of their low production costs and high activation, WBG-based power conversion devices are now the best option. Up until now, no prior research has addressed these reliability activities. Reliability analyses of converters based on silicon or silicon carbide have been published in a few research articles; however, there is scant

literature on power converters based on gallium nitride. Even though these GaN devices that are in the electric vehicle power sector allow for greater range efficiency, a major limitation in this field to overcome is the voltage range. No comprehensive stress test is accessible with respect to dependability and predictive maintenance. Integration with electric motors and battery systems is thus possible in line with these WBG technologies.

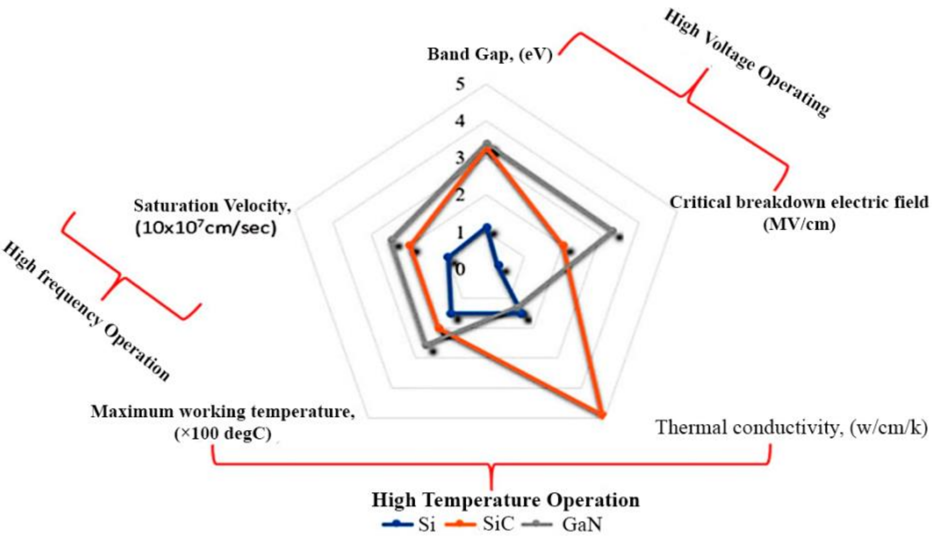

Figure 2. **Evaluation of gallium nitride (GaN), silicon carbides (SiC), and silicon (Si) [73].**

3. Solid Batteries: What Lies Ahead

Literature reviews have shown that lithium batteries are now the market leader in electric vehicle battery technology due to their dominating features [75–78]. Electric vehicles' energy, lifespan of a cycle power output, safety, and, above all else, driving range is all dictated by this battery. The performance and total cost of electric vehicles have been enhanced by numerous distinct scientific breakthroughs in the composition, manufacture, and chemistry of batteries [79].

3.1 Prior Advancements in Lithium Battery Technology

One common way to classify Li-ion batteries is by the material used for the cathode [80, 81]. In contrast, LFP (lithium iron phosphorous) batteries are made using the common steel and phosphate. These batteries have an extremely long lifespan and may provide a great deal of power because of the material's strong olivine structure. The inherent low potential of this technology in comparison to Li+ and its specific capacitance render it unsuitable for high-energy uses, which is a major disappointment. While electric cars commonly use energy-dense technologies like lithium nickel manganese is allowed cobalt oxide (NMC) and lithium

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nickel cobalt aluminium oxide (NCA), LFP is still a good choice for power applications like hybrid cars and power equipment, as well as situations asking a lot of cycles. As a general tendency, both technologies are shifting away from cobalt and towards nickel. Reducing reliance on costly cobalt and ensuring a superior energy density are both achieved by this. Many varieties of NMC are now accessible for commercial use, and this is made possible by studying various stoichiometric proportions. When it comes to NMC111, a NMC532, and NMC622, there is an equal amount of each component. Figure 3 shows that NCA, NMC-532, and the Nagpur Municipal Corporation-622 are state-of-the-art cathode materials, but NMC111 is preferable for higher power workloads because to its manganese content and reduced nickel content. When it comes to their practicality for commercial applications, negative electrodes have numerous limitations. Since 1991, the specific capacitance of silicon and composite the anode has surpassed them as a result of their tiny potential relative to Li+. As of 2016, graphite constituted about 90% of commercial batteries, with amorphous carbon accounting for just 7% and lithium titan ate oxide for just 2%. The raw material appears to be expensive, and these materials have a low energy density, yet they can charge batteries rapidly [82]. Thanks to recent advancements in Li-ion battery research and development, the electrode material on the market today offers a variety of benefits, as shown in Figure 3. The role of selenium in this is going to play a pivotal role very soon. Literature reviews have shown that silicon offers an alternative to graphite as a next-generation anode material, which results in lower pricing (around 8 to 10% lower). More so, even with reduced levels of graphite amalgamated into silicon-based batteries, their life cycles are still

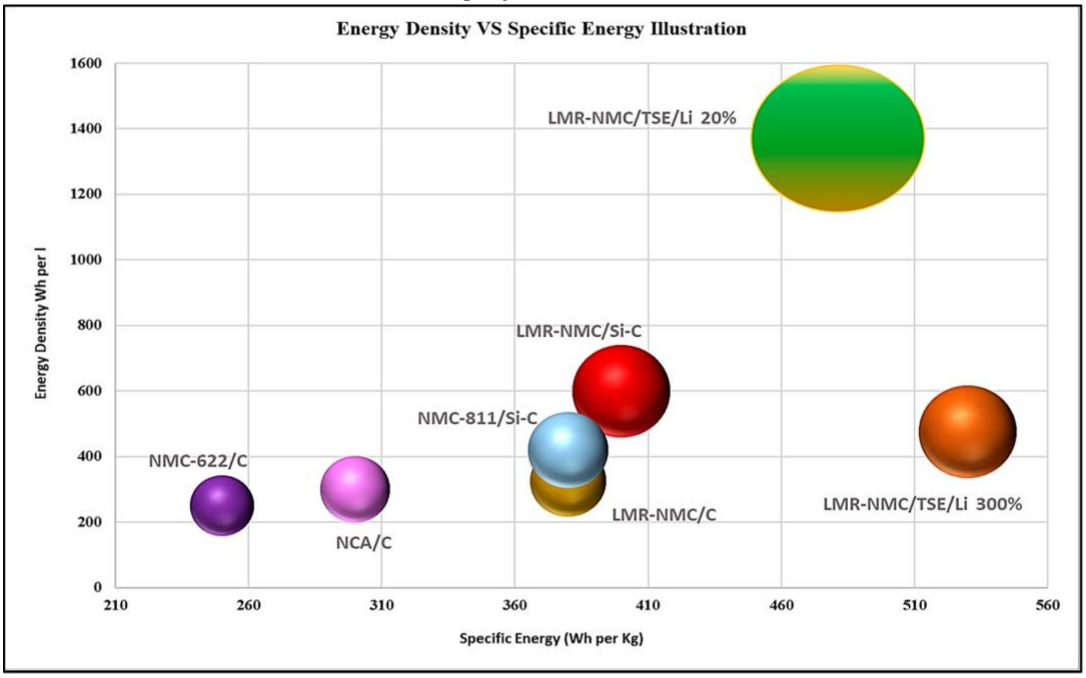

Figure 3. **Representation of comparing energy density with specific energy.**

somewhat limited. Certain instances of this combination have previously taken place, such as the 5% inclusion in Panasonic cells that were subsequently used in Tesla X. It is widely anticipated that current technology will undergo significant advancements in the next years. One consequence of these advancements is the expected increase in nickel-based cathodes, which might reduce the silicon content and directly contribute to a rise in energy density. Along with the anticipated technologies built around lithium-sulfur-oxygen and solid-state batteries, this is something that is anticipated until 2025. Current market forecasts indicate that the lithium-ion battery will form the basis of the next wave of modern technology in the next eight to ten years. The results demonstrated in [84, 85] lead to the conclusion that cobalt or nickel inclusion can enhance energy densities both at the cell and pack levels. Further investigation into these solid-state electrolytes is necessary to confirm this hypothesis. These electrolytes have a higher energy density and are thicker. Unlike other liquid electrolytes, they do not cause combustion and have little effect on concentration polarization voltage losses. These have excellent resistance to dendritic development, which makes them ideal for use as Li-based anodes [86].

A solid electrolyte's capacity for rapid charging is crucial to its suitability for usage in electric vehicle applications. Along these lines, it is important to remember that the Li-dendrite penetration phenomena cause the battery to short circuit at a certain current density. Critical current density

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levels as measured by recent parametric methods are even lower than 0.12 mA/cm2, even though they should be less than 5 mA/cm2 [87, 88]. In addition, charging and discharging require current densities that can be adjusted. It was just recently found out that critical the current density is greater when charging compared to discharging [86].

An important part of getting a long-life cycle and high specific energy is studying the interfaces, like the electrode with electrolyte in solid-state batteries. Additionally, electro-chemical interfacial instability is a common cause of cell failure. As an example, unlike Li+/Li batteries, solid-state electrolytes currently have a viability window of up to 6 V. When the contact between the solid electrolyte and the solid electrode breaks down, the cell impedance could go up. Some methods, such liquid-solid hybrid electrolytes, aim to clarify the instability at the interface [87]. Solid-state batteries are the primary focus of polymers and composite electrolytes due to their inherent orientation towards the energy storage sector. Compared to liquid electrolytes, they offer fewer fire hazards while simultaneously improving mechanical flexibility, processing capacity, and scalability. Poly (ethylene oxy) (PEO) and its metabolites provide intriguing solid-state battery potential due to their large ionic conductivity ranges. While organic liquid electrolytes have come a long way, ion conduction remains a formidable obstacle [89–91]. Like how anode, cathode, and liquid strips are typically assembled in normal Li-ion batteries, solid-state battery production follows a similar pattern. But there are differences in the fabrication of battery pieces and the procedures used to assemble them. Electrodes are inserted after electrolytes such as has been generated, unlike normal Li-ion batteries. To make solid electrolytes, you need to create very toxic hydrogen supplied (H2S) (for sulphides like Li6PS5Cl) and slightly high temperatures (for Li7La3Zr2O12, around 1000 C) [92].

3.2 Solid-State Battery Issues and Possible Fix

In the case of electric vehicles, price per cell or budget per pack is extremely high, and the same is true for power per cell or pack. This objective is deeply held, even though the anticipated degree of security is diminished. Some of the problems that researchers are currently trying to find solutions to are as follows:

- The formation of an interfacial resistance is a result of the weak wetting between the solid electrolyte and lithium. Inadequate wetting of Li causes solid electrolytes, particularly ceramic ones, to display extremely high interfacial resistance. That rules out Li as a potential component of solid-state batteries. It was found that solid electrolytes composed of polymers have lower ionic conductivity and better Li wetting than their ceramic equivalents. Because of this, the Li wetting problem can be tackled by using polymer/ceramic composites as electrolytes [86].
- There are significant issues with dendrite growth and spread when using Li metal in high-power applications. The target value of 5 mA/cm2 is far away from the critical current density for solid-state batteries [87, 88]. Also, the crucial current density needs to go down because plating (charging) while stripping (discharging) are different processes. Although the precise cause and therapeutic therapies are yet unknown, much effort has been made to construct the water molecules as tightly as possible due to the substantial constraints on dendrite propagation in dense microstructures [86]
- Producing, storing, and working with solid electrolytes that exhibit high ionic conductivity presents a number of challenges. They require specialized procedures and oxygen-free settings, which adds to their high cost. Minimizing production costs and making solid electrolyte handling easier are ongoing challenges in this area.

As shown in Figure 4, numerous heats pressing processes are employed throughout the development of a ceramic-based cell. Also, the electrode and electrolyte must have a suitable and smooth relation or contact, so this step is conducted. It has been noted that bulk type solid-state batteries can create enough retention capacity [93], and design engineering can readily accomplish this technique nowadays. Another major limitation of bulk type batteries is their scalability. As a result, polymer composites can be a good choice for these products when mass-produced. Not to mention that when working with high temperatures, Li metal creeps. As a result, current practices advocate including Li metal into a procedure that mitigates creep [94, 95].

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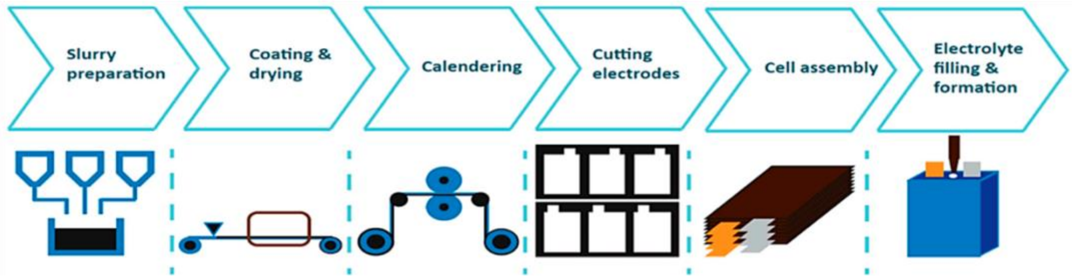

Figure 4. **Battery production for process parameter optimization [94]**

3.3 Power Sources with Built-In Sensors

The performance of batteries undergoes significant variations as time passes. Dendritic short circuits, which can cause capacity diminishing and impedance development, are one of many potentially dangerous material adverse responses that could be at play here. When batteries are in use, it is critical to handle and monitor them correctly. A BMS, or battery management system, is usually employed for this purpose. The BMS ensures that the current, temperature, and voltage of each cell remain within their optimal safety ranges. Battery health shows how well an old battery can retain a charge compared to a brand new one, and a battery's state of state (So C) describes the amount of energy stored information that is specific to a single battery [96]. While direct examination of these characteristics is impossible, measurements of electrical current, voltage, and temper allow for their analysis. At the moment, smart algorithms are used to measure them precisely and optimize them [97]. The sensors used in these all-measurement methods keep tabs on all the relevant metrics that contribute to the overall picture of battery life. Consequently, there is a growing interest in implantable sensors that incorporate battery cells. Using this method, we may gain a better understanding of the chemical processes occurring inside the cells of parasites, measure quantities that have never been measured before, and learn more concerning the physical attributes. The reliability and security of batteries are both enhanced as a result. When the suggested electrolyte's composition, as well as its pressure, strain, enlargement, temperature, and next-generation state estimation methods are computed, a plethora of alternatives arise [98]. Researchers have also recently focused on self-healing batteries. Battery failure occurs due to unwanted chemical changes within the cell. The basic principle of self-healing in batteries is to undo these changes so the battery can function as it did when it was new. A self-healing battery's primary goals will be to restore the conductivity of damaged electrodes, regulate the flow of ions within the cell, and mitigate parasitic side effects. Although self-healing mechanisms are gaining popularity, the battery technology industry has been slow to embrace them because of the challenging chemical environment in which they must function. Some substrates made of polymers have the ability to mend themselves; they are called self-healing polymer substrates or SHPS for short. Their principal objective is to restore conductivity by fixing any damage to the electrodes [99]. To prevent the loss of electrical contact between fragmented active material particles, self-healing polymer binders are employed, for example, in silicon anodes [100]. Another possible concept is functionalized membranes, which have the ability to trap unwanted molecules and prevent them from interacting with other cellular components. But self-healing electrolytes can remove unwanted depositions since they include healing agents [90]. A potential future notion is the contained self-healing molecules. Microcapsules containing medicinal compounds make them up. When the right stimulus is applied, the healing chemicals might be released at the right time. It is important to highlight the interconnected nature of sensing of self-healing processes. The first step in using a smart battery is for a BMS to collect signals from the built-in sensors and process them. When a problem is detected, the BMS will send a signal to the actuator, which will then initiate the correct self-healing process.

This innovative approach will optimize future battery safety, longevity, user confidence, and reliability. Consider embedding the sensor with the battery to the same way as an integrated conductivity alongside temperature (CT) micro-sensor was used in [91] to measure the conductivity of electric battery coolant with high precision; this could be an option for those considering sensor integration with the battery. A sensor that detects temperature cell is a thin-film titanium resistor, and the inter-digital microelectrode is used for resistance detection. The integrated CT sensor's 0.1 S/cm resolution is quite good for a limit of detection. In addition, sensors feature an ideal full-scale measurement error and are equipped with a high-precision signal-collection and processing circuit. The data collected by this sensor, once installed, may be simply transferred to a static IP address through the Iota, where it can run a number of artificial intelligence algorithms to aid in predictive maintenance and additional monitoring.

4. Intelligent Two-Way V2G Networks

The efficient and rapid charging of EV batteries is crucial to their broad adoption. Contemporary electric vehicles typically have a range of 300–400 km before requiring a recharge. The widespread availability of charging stations is one of several challenges.

Table 1*: Charging Duration Level Systems [102]*

System Level	Charging Duration	Output Nature	Location
Ultra-Fast Charging	It Takes approximately 2 minutes.	Three-phase-Vac: dual conversion of 210–600 AC circuit to DC circuit for EVs. Typically, output falls between 800 V and 400 kW.	Off Board 3 Phase
DC Fast Chargers	For 100–130 km of range per hour, charging takes 30 minutes to an hour.	Three-phase Vac: dual conversion from AC circuit 210-600 to DC circuit with an output range of 500	Off-Board 3 Phase
Level 2 Chargers	These are domestic chargers that can be used at home to charge a 16 to 32 km/h vehicle in 4 to 8 hours.	Vac: 240 (according to US standards; 400 according to EU norms). The power is between 3.1 and 19.2 kW, and the output spans from 15 to 80 A.	On-Board single/3 Phase
Level 1 Chargers	This mechanism relies greatly on the type of EV model and takes about 7–10 hours to charge for 3–8 kilometres.	Vac: 240 (according to US standards; 400 according to EU norms). The output is 12–16 A, and the dower is 1.44–1.92 kW.	On-Board Single Phase

Another is the need for rapid charging; and a third is the need to increase power density as well as specific power [101]. Present day usage is characterized by four main types of charging. According to Table 1 [102], there are several kinds of chargers.

Level 3 converters often use off-board systems with sufficient capacity for high-power charging, in contrast to level 1 and two chargers that always charge batteries on-board level 1 and two chargers that always charge batteries on-board. Level 1 and 2 are also known for their slow charging times, which is why you can find them in public places, residences, and private settings rather often. Level 3 charging frameworks, that use DC power based and charge the system extremely quickly, are common in most retail centres [101,102]. Level 2 charging methods take nearly 2 hours and generate about 20 kW of AC power; with this method, an electric vehicle can go up to 200 km. Not only that, but the 150-kW electricity system may cut down on time by 15 minutes compared to the normal one, allowing one to go 200 kilometres. It takes 7 minutes for the 350-kW charging system as well [103,104]. Rectifiers using diodes, matrix rectifiers, and Vienna rectifiers are all examples of three-phase topologies that are different from front-end inverters [105]. A diode rectifier is the most fundamental and most efficient tool for converting power. The output a predetermined voltage is, nevertheless, impacted by the

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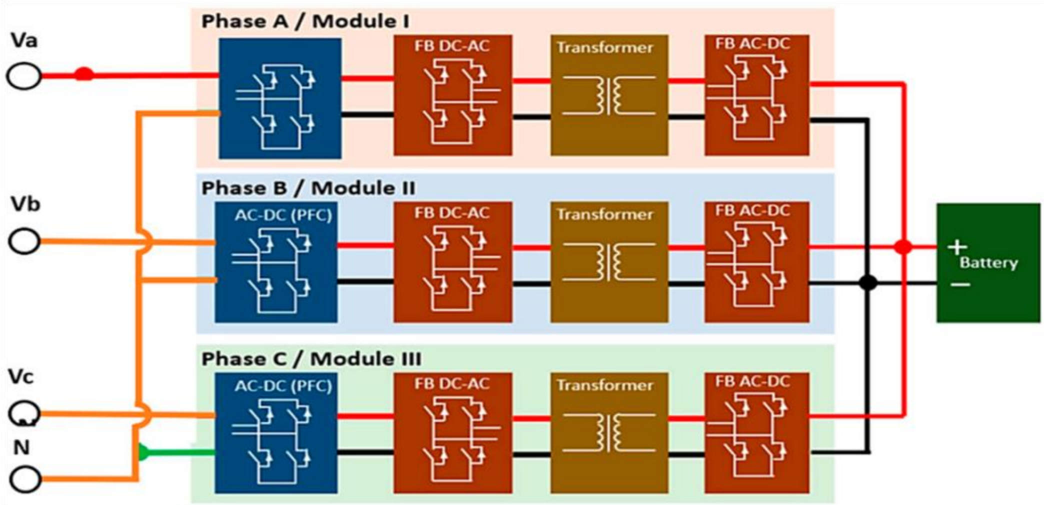

Figure 5. **Architecture of multiphase-bidirectional on-board charger system [107].**

three-phase input voltage. When considering total harmonic distortion (THD), it's not a good thing. To address the transient harmonic distortion (THD) issue, a three phases active front-end (AFE) capacitor can provide changeable DC output voltages in addition to improved factor of return and efficiency in the form of three-phase sine-shaped input current waveforms. Despite its relative obscurity, the city's rectifier is quickly gaining popularity. For off-board fast-charging systems, the AFE boost rectifier is the best three-phase conversion method developed thus far [103,106]. The use of power electronic converters that link to the grid has increased in tandem with the proliferation of battery electric vehicles. Bidirectional power electronic circuits (PECs) allow electric vehicles to serve as both peak power generators and short-term energy storage devices (V2G, or vehicle-to-grid; G2V). In current PEC topologies, active switches are used to manage the bidirectional flow of power instead of diodes. Figure 5 shows the schematic of the multiphase bidirectional on-board charger system.

4.1. Wireless vehicle and vehicle-to-vehicle charging:

Considerations such as high efficiency, low system size, and weight, high reliability, devoid of distortion operation, reduced grid interference, and a few other important metrics should be considered before settling on an off-board charger for a power electronic converter. The appropriate switching frequency, dictated by low gate charge and output capacitance, is essential in this field, and wide band gap technologies are making significant contributions towards these goals while remaining lightweight, portable, and effective. The power transistors based on GaN made this possible. With the development of WBG technology, passive devices, including inductors, caps, and transformers, were also reduced in size and weight [107,108]. Noted as high electron mobility electronics (HEMT), GaN-based transistors are abbreviated as GaN-HEMT. These transistors can withstand voltages up to 660 V and currents ranging from 20-50 A [104,107]. These parts are commonly found in charging stations off-board (OBCs) with a power output of 3.0 kW to 20 kW. Two single-phase bidirectional portable chargers with a totem pole PFC AC-to-DC structure and a unique DC-to-DC stage structure are shown in Figure 6. The galvanic nature-based isolator and reverse power transformation make it possible for the dual active bridge to work, detecting zero voltage and switching on both the primary and secondary sides. As mentioned in [109], this has components that are compact and operate at a set frequency.

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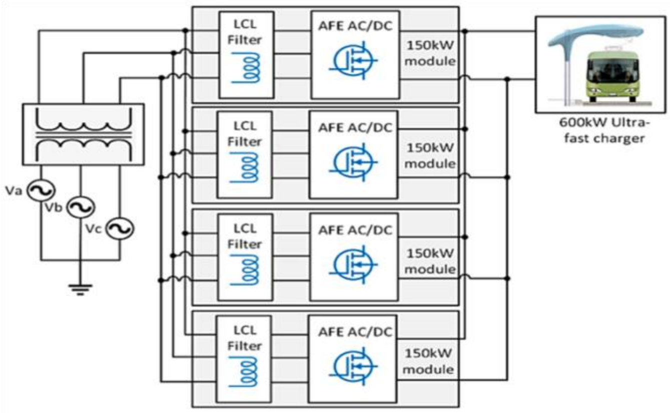

Figure 6. **Topologies for bidirectional OBC systems based on GaN switches [107].**

Because of the large load-power variation, reaching ZVS full range is challenging. Due to zero-voltage switching in the main bridge and zero-current switching on the secondary side, the resonant continuous CLLC architecture (if C is inductance and L is capacitance) seen in Figure 7b is exceedingly efficient. An issue with the CLLC design is that it can't modify the charging output voltage by adjusting the series resonant frequency. Reference [70] suggests replacing modulation of frequencies in the DC-DC phase with DC bus voltage regulation in the PFC level to address this issue. That way, the resonance of the CLLC stage can perform to its full potential [109,110]. Modular converter technology can replace the creation of ultra-fast batteries.

As a 600-go DC ultra-fast charger, the concept calls for four parallel AFE converters to be linked [111]. You can see this in Figure 7. With each 150-kW module, we compared semiconductors based on silicon and silicon carbide. The non-linear electro-thermal modelling framework was utilized to investigate the efficacy of Si (SKM400GB12T4) or SiC (CAS300M12BM2) circuits across various power levels. All relevant datasheet information is present in the calculations for both cases. The vastly superior charging performance of SiC devices compared to silicon-based ones is seen in Figure 8. Due to Si's higher loss than SiC, a wide gap in the band devices can conserve energy in this manner.

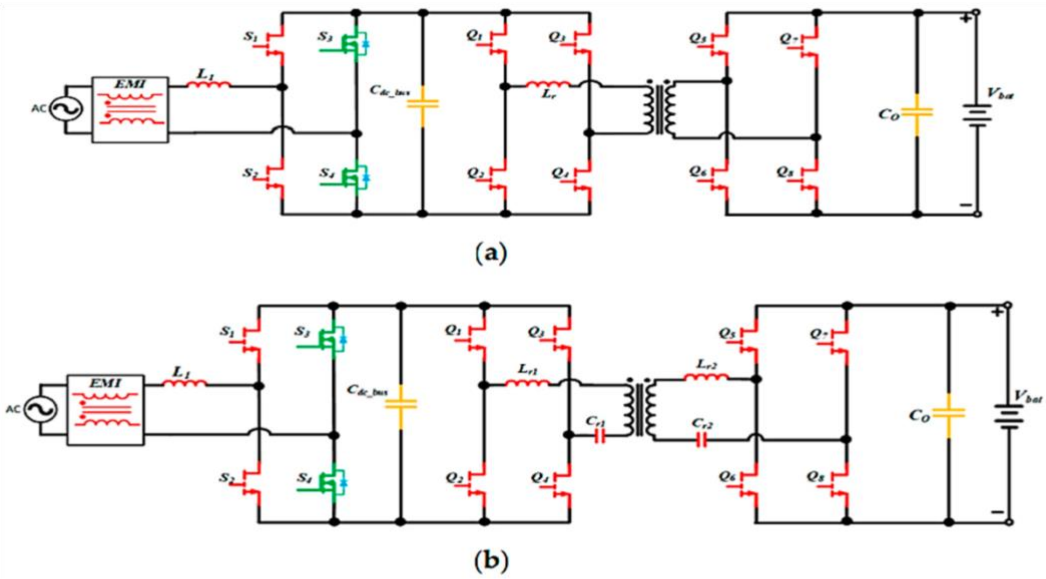

Figure 7. **(a, b) Modular 600 kW DC ultra-fast charger [111].**

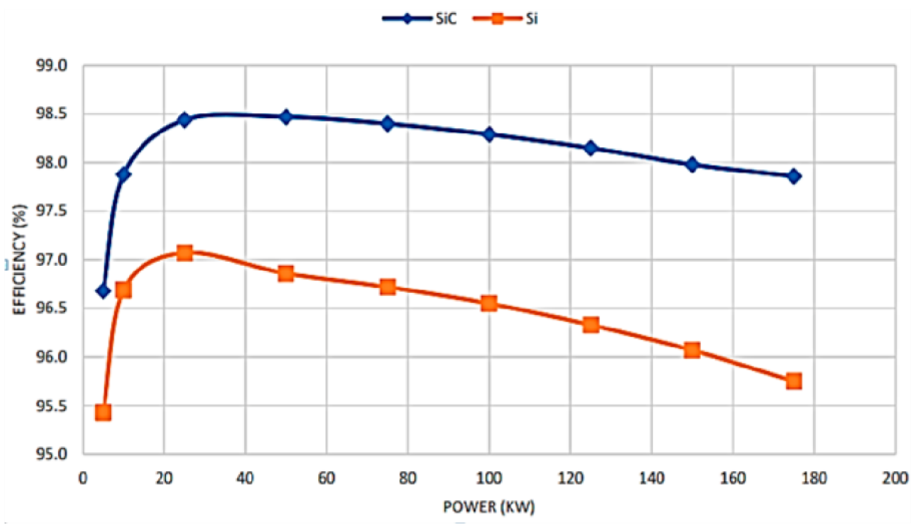

Figure 8. **Si- and SiC-based high-power off-board charging system efficiency map.**

5. Energy and Transportation Transition to Climate Neutral

In order to establish energy-sustainable communities, it is imperative to incorporate renewable energy sources such as hydro, wind, and solar power. When considering the life cycle viewpoint, it is evident that renewable energy sources exert far less impact on climate change compared to conventional energy sources such as coal, oil, or natural gas. This holds true even when accounting for the intermittent nature of renewables within a fully dynamic energy system [112]. The proliferation of DPGs linked to the electricity grid has exacerbated reliability, operational safety, and islanding prevention issues. To meet grid connectivity regulations, better control of distributed generating systems is required [113]. In Belgium, for example, switching to electric vehicles would only lead to a 20% spike in electricity use [114]. The utilization of renewable energy sources is on the rise. When neither the wind nor the sun is present, what then? Either we need to put more money into energy storage or depend more on alternative energy sources. The dimensions of the battery exert a substantial influence on the operational efficiency of electric vehicles. Vehicle batteries can store surplus power from renewable energy sources like solar or wind. For this, the term "smart charge management" is used. Releasing stored energy into the grid is an option during peak power demand. This is known as vehicle-to-grid (V2G) in the technical world.

According to an exhaustive cycle test, the effects of ageing on the battery were unaffected by using the V2H will power a dwelling. Due to the vastly different discharge currents required to power a house and accelerate an automobile, the V2G characteristics do not impact battery ageing [115]. A battery's many useful applications in a local energy community (LEC) make it possible to store energy when it's cheap and release it when it's expensive on the wholesale market. One service that can be provided is capacity credit, which can put off or lessen the necessity of improvements in infrastructure in the manufacturing, transmission, and distribution sectors. In microgrids, batteries placed behind the metro can boost PV self-consumption, which in turn reduces energy costs and helps with backup power. The electricity system is anticipated to change as energy industries and decentralized production grow more prevalent. Electric fleet omnidirectional charging
systems are an essential component of energy management for these systems. They provide adaptable services, help with self-consumption, and keep grid congestion at bay. The techno-economic analysis of a vehicle-to-grid case study is available in reference [116].

On the other hand, bidirectional power transmission is essential for chargers and automobiles to work together. This brings up the previously unsolved matter of contacting the local grid operator. The first insight is that smart grid integration of EVs can take advantage of value streams related to grid balancing [117]. Building a real laboratory to conduct this study is, thus, of the utmost importance. Several prerequisites and principles are laid out in reference to incorporating the V2G into a local energy system [118]. Using the electricity mix in Europe, we find that electric vehicles produce twice as little atmospheric carbon dioxide (CO2) across their lifetimes as petrol or diesel engines. Using Belgium's electrical mix as an example, this might be four times lower. More than a tenfold reduction in oxygen and carbon dioxide pollutants might be possible if vehicles were powered by renewable energy sources [8, 102, 119]. The results for each vehicle's potential to contribute to warming temperatures or global warming are shown

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in Figure 9. The BEV that uses Belgium's power mix gets the worst overall score regarding climate change. Besides human toxicity, the BEV excels in most other mid-range categories compared to traditional petrol and diesel vehicles. The production of auxiliary components like batteries, motors, electronics, etc. significantly influences human toxicity. On the other hand, the BEV outperforms all other vehicles in the examined impact categories when analysing the well-to-wheel (WTW) timing, which is suitable for the Belgian restrictions (and metropolitan environment).

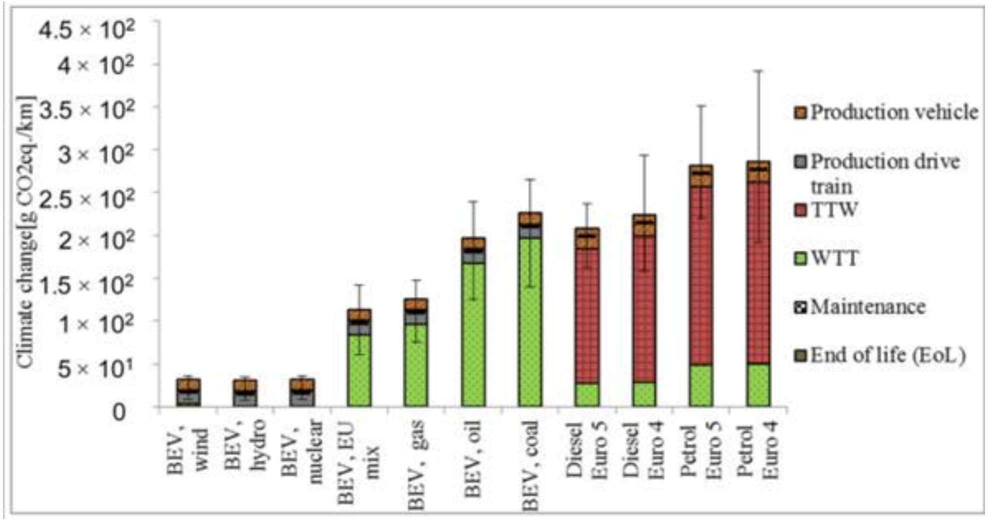

Figure 9. **The findings of the lifespan evaluation (LCA) related to global warming [8].**

Accordingly, a range based LCA approach that accounts for the market diversity of each technology is proposed in reference [120]. Figure 10 shows that when a comprehensive single score level is used to evaluate the BEV, the results are the best.

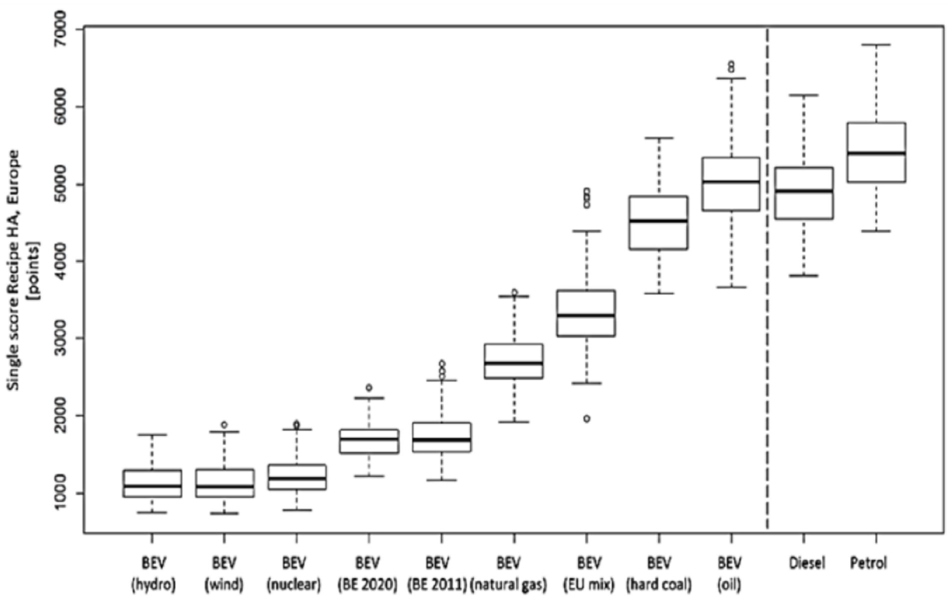

Figure 10. **Results of single-score LCA [8]**

6. Autonomous Electric Vehicles (AEVs)

As the energy and transportation industries become more electrified, these industries are also moving towards increased automation. The automobile industry and other technical sectors are allocating increasing resources to study and build highly automated electric vehicles. In order to bring about greater advantages in terms of reducing expenses, safety, level of service, and, most importantly, environmental benefits, it is

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essential that an electric car be autonomous [121, 122]. Moving from EVs to AEVs allows AVs and EV synergies to be utilized. A new era of data-driven algorithms, AI, strong sensor technology, and intelligent communication is required to bring about this change. Resolving energy demand and fleet management issues might further optimize the transportation infrastructure and its incorporation into the electricity grid while reducing its environmental effects [123]. A smooth integration can only be provided with reliable and fast communication protocols.

6.1 AEVs' Use of Wireless Technology

Autonomous vehicles rely on two types of communication: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I). V2V refers to the communication between individual cars, while V2I refers to the communication between vehicles and any infrastructure. In addition, it includes vehicle-to-home (V2H) communication and vehicle-to-people (V2P) communication. That stands for "vehicle-to-network," or V2N. Figure 1 depicts each of these methods. 11.

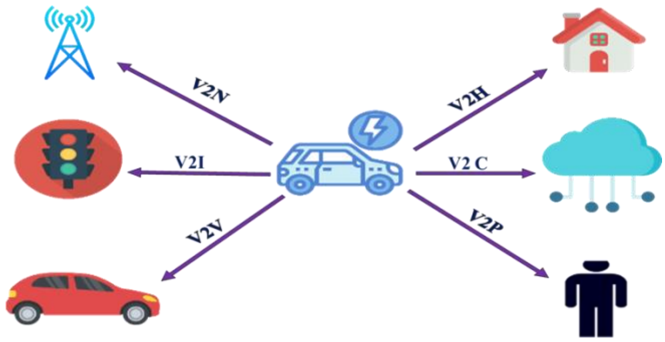

Figure 11. **Protocol illustrations for vehicle-to-everything (V2E) systems.**

There are many options for making this connection, and they all have advantages and disadvantages. Popular wireless communication standards include Bluetooth, 5G, and Wi-Fi. Remember that there may be times when these electromagnetic technologies do not provide sufficient speed for V2V channels and V2I communication, even if it is possible on occasion. A few examples are indoor and underground locations like tunnels and parking lots and rural and urban places with spotty coverage or high levels of electromagnetic interference. Light fidelity (lithium-ion) is an alternative to radio wave transmission, which transfers data through visible and infrared light. Professor Herald Haas first used the term "Li-Fi" in 2011 [123]. He showed how data could have been sent to a photo receiver using the brightness from an inexpensive LED desk lamp. It is possible to accomplish this by altering the light output of currently in use lighting systems, such as streetlights, automobile headlights, and so forth. Adequate photo receivers allow for establishing bidirectional or unidirectional communication links with bandwidths that can provide data rates up to one hundred times higher than Wi-Fi [123]. A technological execution of Li-Fi is shown in Figure 12. A transmitter of a solid-state light source, like a laser diode or an LED, can adjust its output brightness with an electrical driver by regulating the current flow. The widespread usage of solid-state lighting in infrastructure (such as road lights, traffic signals, vehicle headlights, and taillights) makes Li-Fi an easy technology to implement. A new infrastructure must be built compared to comparable systems that use conventional radio frequency (RF) transmission (DSRC, for example). The simplicity of a Li-Fi transmitter makes it possible to upgrade existing lighting systems to use them. In the future, it can facilitate communication between vehicles and other commuters by providing a central location to retrieve relevant data. A high number

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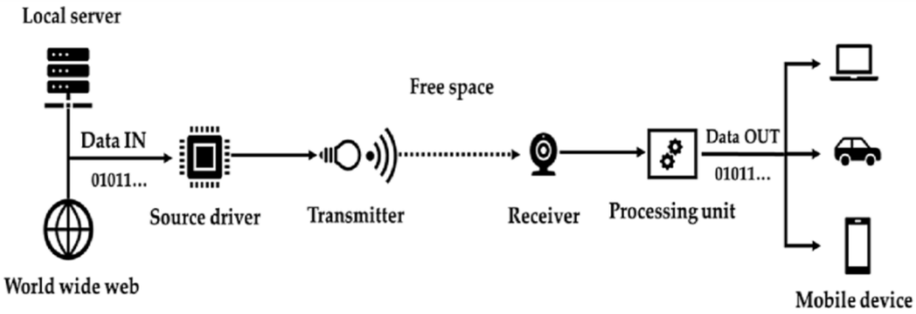

Figure 12. **Application of technology for a Li-Fi downlink channel.**

of easily accessible access points and a low installation cost are the outcomes of this. The existing road lighting infrastructure, which is currently "dumb," can potentially become "smart" with very little work. Yet, as said before, putting it into practice is still challenging. On the other hand, the implementation costs are lower than those of alternatives.

6.2 Shared Electric Autonomous Transportation (SEAVs)

Shared autonomous vehicles (SAVs) are getting a lot of buzz because they could be better, cheaper, and more convenient than the current options for car- and ridesharing [124]. Furthermore, SEAVs, in their electric form, could be environmentally preferable to conventional gas-powered vehicles while still being competitive in terms of cost. People see them as a potential smart mobility component because of this [124]. There are several challenges associated with SEAV use. In order to create viable business models, it is crucial to estimate passenger demand and ascertain passengers' desire to utilize and pay for the procedure [124]. From a mobility standpoint, transport demand must match vehicle availability. SEAVSs can improve mobility, especially for those older or with limited movement [125-127]. This is where the digital gap comes into play, which is worrisome since it means that individuals who are less adept at technology and unable to embrace new technology are socially ostracized. Because AEVs are electric, fleet managers must consider charging needs, driving range, and passenger service. It is crucial to consider the charging stations' expected number, placement, and power levels for setting SEAV fleets [123]. Since most studies on SEAVs that think charging aspects [128,129] have focused on spatial distribution or just rule-based introductions, we still need to learn how to fully assess a location's suitability or how grid constraints and impacts play a role.

The rapid use of electric vehicles heightens concerns over the reliability and power availability of the electrical grid. Electric cars can improve bidirectional charging (vehicle-to-grid) and provide some ancillary services, which could help to balance the electrical grid. On the other hand, research has shown that EVs only modestly increase electricity demand [130]. Furthermore, as mentioned earlier in the chapter, EVs can balance out the intermittent nature of RES, which speeds up their deployment. The highly controllable and coordinated SEAV fleets show promise in this area [131]. Studies currently emphasize the possibilities of SEAV fleets (natural, economic, and service-related) because of their electric and autonomous characteristics, which allow optimized fleet behavior. Nevertheless, it presents a difficult problem for fleet management that calls for additional study and the development of important enabling technologies, such as energy demand and mobility.

7. Autonomous Electric Cars and Driving

This section extensively reviews the supporting technologies that will allow autonomous vehicles to operate, including ADAS and the concept of self-driving electric vehicles (EVs). After that, it finds gaps in the current literature and suggests solutions to those problems.

7.1. ADASs or sophisticated driver assist systems.

ADAS (advanced driver assistance system) technology overview is provided before completely autonomous driving is covered. Accessible driver assistance systems (ADASs) can aid in monitoring, braking, and various alerting tasks, contributing to better road safety. It is possible to use an ADAS to help with parking or keep an eye on things. Along with ADAS, other linked technologies, such as streetlights and traffic data, can make roadways safer for everyone. As ADASs work to improve and gain additional benefits in the coming years, governments may require vehicle installation. The advanced driver assistance systems (ADASs) discussed here are not driverless cars but technologies that help drivers. Driver assistance systems nowadays are progressively getting more advanced in terms of technology. Adaptive cruise control, parking assistance, frontal collision warnings, lane departure warnings, and driver fatigue recognition are the

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main features that most systems aim to offer [132]. A wide variety of ADAS, or advanced driver assistance systems, is currently on the market and might greatly enhance the convenience and security of driving. Assuming they are bought and used, such in-vehicle technologies could greatly benefit older drivers due to age-specific performance limitations.

On the other hand, ADASs are more well-known than they are used, according to a number of market research polls. The disparity in knowledge of and interest in ADAS was investigated in a survey of 32 seniors using semi-structured interviews. Knowledge, experiences, and barriers to utilizing ADASs among the elderly have been the subject of several studies, such as [132]. Parking assistance systems are designed to make backward parking a safe and pleasant experience.

The driver can prevent a collision when reversing because of a reference showing them the direction in which the automobile travels. The purpose of forward collision-avoidance technologies is to alert drivers visually and aurally when they approach the vehicle ahead of them too closely [133]. To determine if a collision is imminent, these systems frequently measure the gap between the two cars and monitor their and the preceding vehicle's speeds [134]. Various sensors can be employed, including Liar, GPS, radar systems, and vision-based ones [135,136]. Typical reasons for driving unconventionally include being drunk, being irresponsible, or being extremely tired [136-144]. These things can alter a driver's demeanor or physical movement. When drivers are tired, they may blink quickly and continuously, nod or swivel their heads, and yawn often [145]. Contrarily, a drunk driver is likely to develop the behavior of consistently responding slowly and with abrupt acceleration or deceleration. Driving carelessly is comparable to driving under the influence to some extent. The driver could be fully aware of the road conditions, but their emotions could be causing them to speed or brake unexpectedly, potentially exceeding the posted limit [145]. Therefore, it is possible to install driver surveillance equipment by keeping an eye on the driver in some way, shape, or form. Direct passenger monitoring systems use several sensors to record the driver's vital signs and movement patterns. As part of passive driver monitoring, we examine the driver's pedal and steering moves and how they react to certain occurrences [146,147]. A warning system will be set into motion upon detecting such unusual behavior.

7.2 Limitations of Driverless Vehicles

There has been a lot of study on autonomous vehicles, but some ground still needs to be explored. This is the first time anyone has discussed an unexpected obstacle in the literature while discussing the autonomous vehicle's parking trajectory. The parking lot is dangerous since a toddler, or an adult could run into it while grabbing something. The driver is aided by installing a rear camera and a device that can identify obstacles in the rear. On the other hand, the driver might not look that way, or the sensors might not go off. An autonomous vehicle should stop if this unexpected obstacle occurs while completing the parking trajectory. For example, the autonomous vehicle shouldn't stop if it sees a balloon as a barrier; it should keep parked. Recent studies have addressed systems that aim to avoid obstacles [148,149]. To account for unanticipated obstacles like a deer running the road, Funk and associates [149] proposed an additional component. The question of how autonomous vehicles should react when an object falls off a car has yet to be discussed in any of the investigations. If a big truck carrying construction iron rods were to have any of the rods come off and smash through the truck window, it might cause catastrophic injuries or perhaps death. The literature does not specifically state that drivers must yield to emergency vehicles, but it is important to note that such cars have some priority at intersections [150]. Electric vehicles that can drive themselves in the future must use a combination of their sensors and those of other cars. Implementing V2V is to raise environmental consciousness by exchanging measurement data. The integration of ADASs and sophisticated lighting infrastructures can be achieved through the use of inexpensive GNSS receivers [131,142], devices that monitor traffic using radar cameras [144], micro-scale traffic data [123-146], and other networks.

While a driverless car certainly has numerous advantages, it also has the potential to bring about several societal problems. The question of who should pay in the event of an accident is serious; manufacturers or insurance companies should shoulder this burden [107,108]. Some have argued that if we treat self-driving and human drivers similarly, we can ensure that they will only be held accountable for actions linked to carelessness (as stated in [148]). It's simpler to say than to do: a car should have the same rights as a person. Vehicles ought to be subject to tort law in the same way that canines are [119]. This is similar to the dog law. There is a lot of ground to cover before autonomous vehicles can be entered into practice, as the writers should have mentioned how the regulation could be applied to them. Because implementing such a system shouldn't jeopardize road safety, it was stated in

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[139] that producers should have control over their designs and that items should undergo thorough testing before distribution. Before the public and manufacturers can embrace autonomous vehicles, it is evident that the laws governing them need to be improved [120-123].

8. Challenges and Opportunities

Here, we look at the most current research roadblocks for connected, autonomous, and intelligent electric car technologies. The following information is given: [134-143]. Because they do away with impairments like alcohol, attention, fatigue, and slow decision-making, autonomous vehicles improve drivers' decision-making abilities. The ability of these technologies to surpass human decision-

making abilities while driving is largely due to these factors [149]. Consequently, autonomous vehicles with AI present significant challenges in real-time responses and mistake prevention. The importance of safety and performance metrics for autonomous cars has been the subject of lots of studies. These metrics should account for hardware failures, programming mistakes, unexpected occurrences and entities, cyber-attack probabilities, and threats. Creating and analysing these indicators in real-time will be of utmost importance going forward. Appeared in Table 2 is the comparative assessment of autonomous driving systems.

Table 2. *Challenges and Future Direction of Modern Intelligent Vehicle Technologies.*

Key Findings	Challenges and Features	Year
This paper discussed the importance of deep learning in autonomous driving. Here, a number of problems with autonomous vehicles are looked at, and deep learning and artificial intelligence are used to propose answers.	This work can broaden the understanding of deep learning's role and how it integrates with other autonomous driving assistance systems. It incorporates components of contemporary infrastructure, like cloud, blockchain, and Internet of Things technologies [134].	2020
A taxonomy for self-driving cars was created as a result of this study's investigation and classification of automated driving as it stands today. This work also produced an idea for a hybrid architecture that combines computer and human intelligence. The car's design served as an overview of autonomous driving. A taxonomy of autonomous driving systems, akin to self-driving cars, was developed as a result of this study. Information integrity and machine-human interaction were given more importance than driver replacement alone.	To this endeavour, discourse and safety criteria can be added. Blockchain technology may be utilized to solve data security and privacy problems, and the suggested hybrid architecture includes a safety monitoring system that can be expanded with other cutting-edge tools like drones and cloud computing sets. State-of-the-art networks like SG networks can be used to study further performance issues.	2020
The use of drones in autonomous systems is the main topic of this article. Furthermore, discussed are the anti-collision strategies for drone mobility and traffic surveillance. The number of drones and on-road cars is changed in order to analyse the data.	Applications of this technique include real-time autonomous system deployment and monitoring. But still. A detailed investigation into the interaction between drones and autonomous vehicles is necessary [136].	2021
This paper presents a blockchain-based architecture supporting network and autonomous vehicles' safety and security.	The main technological components and their connections to driving, systems, and autonomous cars are briefly reviewed in this article. By delving further into technical matters, this work can be further expanded [137].	2020

Control systems, driving components of the system, interactions across vehicle-to-everything groups, and risk assessment and survey programmers are only some of the many domains that cyber-attacks can infiltrate. The primary forms of threats that require investigation and examination are assaults on sensors, assaults on mobile applications and vehicle information systems, attacks on Iota infrastructure, brutal assaults, and side-channel attacks. In addition, cyber security uses AI to detect attacks. Autonomous architecture is another interesting aspect. Important architectural subsystems to study include autonomous systems that incorporate sensors and actuators, control mechanisms, the monitored vehicle environment, external control variables, visibility, speed, and object recognition. The proliferation of driverless cars will drive up the cost of communication. Implicitly lowering performance or increasing communication fault causes packet loss or delay. Autonomous vehicles and their widespread use are critical to human survival. One shortcoming of earlier attempts was the need for comprehensive studies examining emerging developments, like the application of deep learning and the Internet of Things.

Additionally, it is essential to address intelligent software and tools, which still need to be discussed in the existing literature. Effective simulation also needs improvement. Improving object recognition, navigation, sensors, etc., and cloud computing are all necessary to build self-driving automobiles. Autonomous vehicles can use predictive models to determine their routes and how to control their mobility. There has to be a more sophisticated AI-based approach for AVs. Care for every part of the real-time architecture is essential. Scene recognition, for example, requires object tracking and object detection [139]. There must be a comprehensive representation of current AV designs [140]. The design of the AVs should handle system failures and scalability management. Autonomous vehicles (AVs) need real-time architecture to perceive their surroundings and communicate with other cars in real-time. Automated systems can achieve this. For AVs to be accurate, their infrastructure and devices—the principal agents—must work together [141]. The SAE uses a scale from 0 (no automation) to 5 (full performance) to classify automation levels.

Companies and academics are putting in much time and effort to attain level 5 [81]. The following classes of components are required for design following SAEJ 3016:

- Vehicle control is the primary focus in the operational class.
- In addition to route planning, object detection, and tracking are covered in the tactical class, which is the second level.
- At number three, the strategic class is where one might think about trip planning, which is undoubtedly crucial.

A lot of work has gone into designing, developing, validating, and monitoring AVs in real-time with the help of AI. Perception, route planning, and driving decision-making are all areas where AI shines. AVs use AI for the following purposes:

- The paths that autonomous vehicles take are determined by a prediction algorithm.
- Many sensors provide AVs with real-time data, which they intelligently employ.
- Autonomous cars look to their historical data when deciding on a speed and course.

The future of autonomous vehicles is uncertain due to the possibility of a deliberate assault on the machine learning system that disrupts its functioning. One example of such an attack is the practice of covering stop signs with stickers to make them harder to see. These changes could trigger AI to mistakenly identify things, leading the autonomous car to act in a way that endangers people. Therefore, it is necessary to investigate RFID or Iota-based AI solutions to these problems. Many believe that autonomous vehicles would significantly alter the way we live. It is the responsibility of lawmakers to design laws that improve the social and economic fabric of the nation. The possibility that an AV could become a "killer app" with far-reaching effects has been the subject of research. Though they are still in the early stages of research, AVs will already have far-reaching consequences.

As a result, research into the safety measures should precede their implementation in actual settings. Autonomous vehicles can navigate their environments with the help of deep neural networks (DNNs). Because of their shared reliance on trial-and-error learning, human brains and DNNs are quite similar. Regarding autonomous driving, the exact number of DNNs needed is not determined by any concrete criterion. So, a thorough investigation is required down the road. An independent driving system takes millions of connections between cars, humans, and other devices to work in a real-world road setting. A high-end, potentially expensive infrastructure is required to manage such a vast infrastructure. Therefore, research into how AI can make the most of the infrastructure to facilitate seamless autonomous experiences is necessary. Improved route selection and object identification capabilities for autonomous cars should be realized by developing smarter tools and software in the future. Since real-time choices are made, data exchange should be faster [142-144]. Autonomous systems rely on machine learning algorithms to monitor machine behaviour and foresee potential issues. The solution improves operating efficiency, prolongs asset life, and decreases unscheduled downtime expenses. It is essential to find the most effective algorithmic learning algorithms and methods for keeping tabs on a machine or its operations. In the future, we can investigate this task more. Retinopathies, which include glaucoma, hypertension, diabetes, and others, may be preventable with early vascular detection using fundus imaging [125-127]. This research aims to find a better way to leverage both traditional template-matching methods and cutting-edge deep learning techniques for optimal performance. Train your convolutional neural network to detect vessels and backgrounds in photos using a U-shaped, fully connected network (Unit). Exploring additional cutting-edge technologies like quantum and blockchain for AV mobile computer networks is possible [122-125]. Autonomous cars communicate data via a wireless sensor network [146–148].

9. Conclusions

This document presents all of the most recent findings in electric vehicle innovation and technology. This is on top of the little research on the various batteries and their levels. Also covered are safety concerns and how the present market complements shared autonomous electric vehicles. Because of this, we have concluded that current advanced driving systems for assistance require quick improvement; this review study also addresses this element. The most recent advances in battery technology and theories on the evolution of solid-state batteries and their interactions with other systems have been discussed. Integrating embedded sensors into the cell and developing self-healing batteries are two examples of how this state-of-the-art technology improves battery safety and dependability. Electric vehicles (EVs) can benefit from digital twins (DTs) in some ways, including cost-effectiveness and more reliable powertrain design. Powertrains that are novel, functional, and affordably priced are thus provided with new directions and trends.

Regarding fully autonomous vehicles, drivers won't have to worry about that complicated task. This means less traffic, less gas consumption, and no accidents while parking. The complete implementation of autonomous vehicles is a precondition for the ideas presented in the literature, which may take some time to materialize. How an autonomous automobile should respond to a negligent motorist is still in the air. Examples of careless driving include Following too closely, going too fast for conditions, Not using turn signals, continuing through stop signs without halting, Not yielding the right of way. Researchers have also focused on interactions between four-wheel drives and have ignored interactions between motorcycles and autonomous vehicles. When it comes to transportation, it's not easy to figure out how an auto should handle a situation when motorcyclists are at high risk of death. The capacity to analyse driving behaviour is now a feature of modern technologies, which can aid in preventing unusual driving patterns. When an electric vehicle exhibits abnormal behaviour, the devices can control its lateral movement. With the successful demonstration of neural-network-based autonomous driving, NVIDIA has set a new standard for independent driving software. Autonomous transverse control is the biggest challenge for autonomous vehicles. An end-to-end model is quite promising in providing a complete software stack for automated driving. Despite not being ready for market availability, this technology is a major step towards developing self-driving cars. Implementing an end-to-end framework is the main subject of the work presented in the article. The complexities of creating a successful end-to-end model are emphasized in an effort to shed light on deep-taking classes and the software required for training neural networks. In a multilane track, such as the one used for training in the current research, the model demonstrated an autonomy of 96.62%. With an accuracy rate of 89.02%, the model guided the vehicle safely along unexplored, single-lane tracks. Autonomous driving in unknown and unfamiliar surroundings is now within reach, thanks to the combination of AI with end-to-end learning and behavioural cloning.

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One of the many appealing aspects of electric vehicles is the way their carbon footprints and power systems that use renewable energy sources work together. The possibility of reducing CO_2 emissions from electric vehicle charging is being studied in the context of coordinated charging. This could involve charging solely if the grid's carbon intensity (gCO2/kWh) is little and absorption of excess wind generation when it would not otherwise be curtailed. A method for scheduling charge events that aims for the lowest intensity of carbon of charging while respecting Av and network limits is presented as a time-coupled linearized DNA optimal power flow formulation. This method is based on plugging-in periods produced from a large travel dataset. The effectiveness of autonomous vehicles has also been greatly enhanced with the development of artificial intelligence, which is another argument. Therefore, this manuscript also includes an outline of independent automobiles. Sensors are essential for an autonomous car to collect and transmit data. With this data, we can build an improved structure for lane preserving, lane changing, and obstacle detection.

Nevertheless, different sensors do have their limitations. Despite the potential cost savings, image processing techniques are vulnerable to environmental and climatic variables. Consequently, further research is needed to improve the accuracy of cheap sensors or reduce the price of high-reliability sensors so they can be mass-produced.

References

[1]. Chan, C.C.; Wong, Y.S.; Bouscayrol, A.; Chen, K. Powering sustainable mobility: Roadmaps of electric, hybrid, and fuel cell vehicles [point of view]. Proc. IEEE **2009**, 97, 603–607. [CrossRef]

[2]. Lebeau, K.; Van Mierlo, J.; Lebeau, P.; Mairesse, O.; Macharis, C. Consumer attitudes towards battery electric vehicles: A large-scale survey. Int. J. Electr. Hybrid Veh. **2013**, 5, 28. [CrossRef]

[3]. Bloomberg NEF. BloombergNEF's 2019 Battery Price Survey BNEF. Available online: https://about.bnef.com/blog/batterypackprices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/ (accessed on 3 February 2023).

[4]. Berckmans, G.; Messagie, M.; Smekens, J.; Omar, N.; Vanhaverbeke, L.; Van Mierlo, J. Cost Projection of State of the Art Lithium-Ion Batteries for Electric Vehicles Up to 2030. Energies **2017**, 10, 1314. [CrossRef]

[5]. Vijayagopal, R.; Rousseau, A. Benefits of Electrified Powertrains in Medium- and Heavy-Duty Vehicles. World Electr. Veh. J. **2020**, 11, 12. [CrossRef]

[6]. Simeu, S.K.; Brokate, J.; Stephens, T.; Rousseau, A. Factors Influencing Energy Consumption and Cost-Competiveness of Plug-in Electric Vehicles. World Electr. Veh. J. **2018**, 9, 23. [CrossRef]

[7]. Islam, E.S.; Moawad, A.; Kim, N.; Rousseau, A. Vehicle Electrification Impacts on Energy Consumption for Different ConnectedAutonomous Vehicle Scenario Runs. World Electr. Veh. J. **2020**, 11, 9. [CrossRef]

[8]. Messagie, M.; Boureima, F.-S.; Coosemans, T.; Macharis, C.; Mierlo, J.V. A Range-Based Vehicle Life Cycle Assessment Incorporating Variability in the Environmental Assessment of Different Vehicle Technologies and Fuels. Energies **2014**, 7, 1467–1482. [CrossRef]

[9]. Marmiroli, B.; Messagie, M.; Dotelli, G.; Van Mierlo, J. Electricity Generation in LCA of Electric Vehicles: A Review. Appl. Sci. **2018**, 8, 1384. [CrossRef]

[10]. Rangaraju, S.; De Vroey, L.; Messagie, M.; Martens, J.; Van Mierlo, J. Impacts of electricity mix, charging profile, and driving behavior on the emissions performance of battery electric vehicles: A Belgian case study. Appl. Energy **2015**, 148, 496–505. [CrossRef]

[11]. Islam, S.; Iqbal, A.; Marzband, M.; Khan, I.; Al-Wahedi, A.M. State-of-the-art vehicle-to-everything mode of operation of electric vehicles and its future perspectives. Renew. Sustain. Energy Rev. **2022**, 166, 112574. [CrossRef]

[12]. Yong, J.Y.; Ramachandaramurthy, V.K.; Tan, K.M.; Mithulananthan, N. A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects. Renew. Sustain. Energy Rev. **2015**, 49, 365–385. [CrossRef]

[13]. Shariff, S.M.; Iqbal, D.; Alam, M.S.; Ahmad, F. A State of the Art Review of Electric Vehicle to Grid (V2G) technology. IOP Conf. Ser. Mater. Sci. Eng. **2019**, 561, 012103. [CrossRef]

[14]. Alam, F.; Mehmood, R.; Katib, I.; Albogami, N.N.; Albeshri, A. Data Fusion and IoT for Smart Ubiquitous Environments: A Survey. IEEE Access **2017**, 5, 9533–9554. [CrossRef]
[15]. Munoz, R.; Vilalta, R.; Yoshikane, N.; Casellas, R.; Martinez, R.; Tsuritani, T.; Morita, I. Integration of IoT, Transport SDN, and Edge/Cloud Computing for Dynamic Distribution of IoT Analytics and Efficient Use of Network Resources. J. Light. Technol. **2018**, 36, 1420–1428. [CrossRef]
[16]. Frustaci, M.; Pace, P.; Aloi, G.; Fortino, G. Evaluating Critical Security Issues of the IoT World: Present and Future Challenges. IEEE Internet Things J. **2018**, 5, 2483–2495. [CrossRef]
[17]. Ngu, A.H.; Gutierrez, M.; Metsis, V.; Nepal, S.; Sheng, Q.Z. IoT middleware: A survey on issues and enabling technologies. IEEE Internet Things J. **2017**, 4, 1–20. [CrossRef]
[18]. Kannan, M.; Mary, L.W.; Priya, C.; Manikandan, R. Towards smart city through virtualized and computerized car parking system using arduino in the internet of things. In Proceedings of the 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA), Gunupur, India, 13–14 March 2020; pp. 1–6. [CrossRef]
[19]. Kuutti, S.; Fallah, S.; Katsaros, K.; Dianati, M.; Mccullough, F.; Mouzakitis, A. A Survey of the State-of-the-Art Localization Techniques and Their Potentials for Autonomous Vehicle Applications. IEEE Internet Things J. **2018**, 5, 829–846. [CrossRef]
[20]. Kong, L.; Khan, M.K.; Wu, F.; Chen, G.; Zeng, P. Millimeter-wave wireless communications for IoT-cloud supported autonomous vehicles: Overview, design, and challenges. IEEE Commun. Mag. **2017**, 55, 62–68. [CrossRef]
[21]. Honnaiah, P.J.; Maturo, N.; Chatzinotas, S. Foreseeing semi-persistent scheduling in mode-4 for 5G enhanced V2X communication. In Proceedings of the 2020 IEEE 17th Annual Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, USA, 10–13 January 2020; pp. 1–2. [CrossRef]
[22]. Li, L.; Liu, Y.; Wang, J.; Deng, W.; Oh, H. Human dynamics based driver model for autonomous car. IET Intell. Transp. Syst. **2016**, 10, 545–554. [CrossRef]
[23]. Andresen, L.; Brandemuehl, A.; Honger, A.; Kuan, B.; Vödisch, N.; Blum, H.; Reijgwart, V.; Bernreiter, L.; Schaupp, L.; Chung, J.J.; et al. Accurate mapping and planning for autonomous racing. In Proceedings of the 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Las Vegas, NV, USA, 24 October–24 January 2020; pp. 4743–4749. [CrossRef]
[24]. Bensekrane, I.; Kumar, P.; Melingui, A.; Coelen, V.; Amara, Y.; Chettibi, T.; Merzouki, R. Energy Planning for Autonomous Driving of an Over-Actuated Road Vehicle. IEEE Trans. Intell. Transp. Syst. **2020**, 22, 1114–1124. [CrossRef]
[25]. Choi, Y.-J.; Hur, J.; Jeong, H.-Y.; Joo, C. Special issue on V2X communications and networks. J. Commun. Netw. **2017**, 19, 205–208. [CrossRef]
[26]. Chen, S.; Hu, J.; Shi, Y.; Peng, Y.; Fang, J.; Zhao, R.; Zhao, L. Vehicle-to-Everything (v2x) Services Supported by LTE-Based Systems and 5G. IEEE Commun. Stand. Mag. **2017**, 1, 70–76. [CrossRef]
[27]. Bai, B.; Chen, W.; Ben Letaief, K.; Cao, Z. Low Complexity Outage Optimal Distributed Channel Allocation for Vehicle-to-Vehicle Communications. IEEE J. Sel. Areas Commun. **2010**, 29, 161–172. [CrossRef]
[28]. Zhang, R.; Cheng, X.; Yao, Q.; Wang, C.-X.; Yang, Y.; Jiao, B. Interference Graph-Based Resource-Sharing Schemes for Vehicular Networks. IEEE Trans. Veh. Technol. **2013**, 62, 4028–4039. [CrossRef]
[29]. Du, L.; Dao, H. Information Dissemination Delay in Vehicle-to-Vehicle Communication Networks in a Traffic Stream. IEEE Trans. Intell. Transp. Syst. **2014**, 16, 66–80. [CrossRef]
[30]. Mei, J.; Zheng, K.; Zhao, L.; Teng, Y.; Wang, X. A Latency and Reliability Guaranteed Resource Allocation Scheme for LTE V2V Communication Systems. IEEE Trans. Wirel. Commun. **2018**, 17, 3850–3860. [CrossRef]
[31]. Belanovic, P.; Valerio, D.; Paier, A.; Zemen, T.; Ricciato, F.; Mecklenbrauker, C.F. On Wireless Links for Vehicle-to-Infrastructure Communications. IEEE Trans. Veh. Technol. **2009**, 59, 269–282. [CrossRef]
[32]. Liu, N.; Liu, M.; Cao, J.; Chen, G.; Lou, W. When transportation meets communication: V2P over VANETs. In Proceedings of the 2010 IEEE 30th International Conference on Distributed Computing Systems, Genoa, Italy, 21–25 June 2010; pp. 567–576. [CrossRef]

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November, 2023
Texas, USA

[33]. Lee, S.; Kim, D. An Energy Efficient Vehicle to Pedestrian Communication Method for Safety Applications. Wirel. Pers. Commun. **2015**, 86, 1845–1856. [CrossRef]
[34]. Merdrignac, P.; Shagdar, O.; Nashashibi, F. Fusion of Perception and V2P Communication Systems for the Safety of Vulnerable Road Users. IEEE Trans. Intell. Transp. Syst. **2016**, 18, 1740–1751. [CrossRef]
[35]. Campolo, C.; Molinaro, A.; Iera, A.; Menichella, F. 5G Network Slicing for Vehicle-to-Everything Services. IEEE Wirel. Commun. **2017**, 24, 38–45. [CrossRef]
[36]. Abboud, K.; Omar, H.A.; Zhuang, W. Interworking of DSRC and Cellular Network Technologies for V2X Communications: A Survey. IEEE Trans. Veh. Technol. **2016**, 65, 9457–9470. [CrossRef]
[37]. Wei, Q.; Wang, L.; Feng, Z.; Ding, Z. Wireless Resource Management in LTE-U Driven Heterogeneous V2X Communication Networks. IEEE Trans. Veh. Technol. **2018**, 67, 7508–7522. [CrossRef]
[38]. Naik, G.; Choudhury, B.; Park, J.-M. IEEE 802.11bd & 5G NR V2X: Evolution of Radio Access Technologies for V2X Communications. IEEE Access **2019**, 7, 70169–70184. [CrossRef]
[39]. Saiteja, P.; Ashok, B. Critical review on structural architecture, energy control strategies and development process towards optimal energy management in hybrid vehicles. Renew. Sustain. Energy Rev. **2022**, 157, 112038. [CrossRef]
[40]. Chidambaram, K.; Ashok, B.; Vignesh, R.; Deepak, C.; Ramesh, R.; Narendhra, T.M.; Usman, K.M.; Kavitha, C. Critical analysis on the implementation barriers and consumer perception toward future electric mobility. Proc. Inst. Mech. Eng. Part D J. Automob. Eng. **2022**, 09544070221080349. [CrossRef]
[41]. Dueholm, J.V.; Kristoffersen, M.S.; Satzoda, R.K.; Moeslund, T.B.; Trivedi, M.M. Trajectories and Maneuvers of Surrounding Vehicles with Panoramic Camera Arrays. IEEE Trans. Intell. Veh. **2016**, 1, 203–214. [CrossRef]
[42]. Han, L.; Zheng, K.; Zhao, L.; Wang, X.; Shen, X. Short-Term Traffic Prediction Based on DeepCluster in Large-Scale Road Networks. IEEE Trans. Veh. Technol. **2019**, 68, 12301–12313. [CrossRef]
[43]. Shabir, B.; Khan, M.A.; Rahman, A.U.; Malik, A.W.; Wahid, A. Congestion Avoidance in Vehicular Networks: A Contemporary Survey. IEEE Access **2019**, 7, 173196–173215. [CrossRef]
[44]. MacHardy, Z.; Khan, A.; Obana, K.; Iwashina, S. V2X access technologies: Regulation, research, and remaining challenges. IEEE Commun. Surv. Tutor. **2018**, 20, 1858–1877. [CrossRef]
[45]. Hu, Q.; Luo, F. Review of secure communication approaches for in-vehicle network. Int. J. Automot. Technol. **2018**, 19, 879–894. [CrossRef]
[46]. Masini, B.M.; Bazzi, A.; Zanella, A. A Survey on the Roadmap to Mandate on Board Connectivity and Enable V2V-Based Vehicular Sensor Networks. Sensors **2018**, 18, 2207. [CrossRef] [PubMed]
[47]. Wang, X.; Mao, S.; Gong, M.X. An Overview of 3GPP Cellular Vehicle-to-Everything Standards. GetMobile Mob. Comput. Commun. **2017**, 21, 19–25. [CrossRef]
[48]. Chen, L.; Englund, C. Cooperative intersection management: A survey. IEEE Trans. Intell. Transp. Syst. **2015**, 17, 570–586. [CrossRef]
[49]. Dixit, S.; Fallah, S.; Montanaro, U.; Dianati, M.; Stevens, A.; Mccullough, F.; Mouzakitis, A. Trajectory planning and tracking for autonomous overtaking: State-of-the-art and future prospects. Annu. Rev. Control **2018**, 45, 76–86. [CrossRef]
[50]. Bresson, G.; Alsayed, Z.; Yu, L.; Glaser, S. Simultaneous localization and mapping: A survey of current trends in autonomous driving. IEEE Trans. Intell. Veh. **2017**, 2, 194–220. [CrossRef]
[51]. Bousselham, M.; Benamar, N.; Addaim, A. A new security mechanism for vehicular cloud computing using fog computing system. In Proceedings of the 2019 International Conference on Wireless Technologies, Embedded and Intelligent Systems (WITS), Fez, Morocco, 3–4 April 2019; pp. 1–4. [CrossRef]
[52]. Mekki, T.; Jabri, I.; Rachedi, A.; ben Jemaa, M. Vehicular cloud networks: Challenges, architectures, and future directions. Veh. Commun. **2017**, 9, 268–280. [CrossRef]
[53]. Boukerche, A.; De Grande, R.E. Vehicular cloud computing: Architectures, applications, and mobility. Comput. Netw. **2018**, 135, 171–189. [CrossRef]
[54]. Yang, Q.; Zhu, B.; Wu, S. An Architecture of Cloud-Assisted Information Dissemination in Vehicular Networks. IEEE Access **2016**, 4, 2764–2770. [CrossRef]

[55]. Meneguette, R.I.; Boukerche, A.; de Grande, R. SMART: An Efficient Resource Search and Management Scheme for Vehicular Cloud-Connected System. In Proceedings of the IEEE Global Communications Conference (GLOBECOM), Washington, DC, USA, 4–8 December 2016; pp. 1–6. [CrossRef]
[56]. De Souza, A.B.; Rego, P.A.L.; de Souza, J.N. Exploring computation offloading in vehicular clouds. In Proceedings of the 2019 IEEE 8th International conference on cloud networking (CloudNet), Coimbra, Portugal, 4–6 November 2019; pp. 1–4. [CrossRef]
[57]. Sharma, V.; You, I.; Yim, K.; Chen, R.; Cho, J.H. BRIoT: Behavior rule specification-based misbehavior detection for IoT-embedded cyber-physical systems. IEEE Access **2019**, 7, 118556–118580. [CrossRef]
[58]. Salahuddin, M.A.; Al-Fuqaha, A.; Guizani, M. Software-Defined Networking for RSU Clouds in Support of the Internet of Vehicles. IEEE Internet Things J. **2014**, 2, 133–144. [CrossRef]
[59]. Tran, D.-D.; Vafaeipour, M.; El Baghdadi, M.; Barrero, R.; Van Mierlo, J.; Hegazy, O. Thorough state-of-the-art analysis of electric and hybrid vehicle powertrains: Topologies and integrated energy management strategies. Renew. Sustain. Energy Rev. **2020**, 119, 109596. [CrossRef]
[60]. Hannan, M.A.; Hoque, M.D.M.; Hussain, A.; Yusof, Y.; Ker, A.P.J. State-of-the-Art and Energy Management System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues and Recommendations. IEEE Access Spec. Sect. Adv. Energy Storage Technol. Appl. **2018**, 6, 19362–19378. [CrossRef]
[61]. Chen, K.; Bouscayrol, A.; Lhomme, W. Energetic Macroscopic Representation and Inversion-based Control: Application to an Electric Vehicle with an Electrical Differential. J. Asian Electr. Veh. **2008**, 6, 1097–1102. [CrossRef]
[62]. Chan, C.C.; Bouscayrol, A.; Chen, K. Electric, Hybrid, and Fuel-Cell Vehicles: Architectures and Modeling. IEEE Trans. Veh. Technol. **2009**, 59, 589–598. [CrossRef]
[63]. Koot, M.; Kessels, J.T.; De Jager, B.; Heemels, W.; Van den Bosch, P.; Steinbuch, M. Energy management strategies for vehicular electric power systems. IEEE Trans. Veh. Technol. **2005**, 54, 771–782. [CrossRef]
[64]. Hofman, T.; Steinbuch, M.; Van Druten, R.; Serrarens, A. Rule-based energy management strategies for hybrid vehicles. Int. J. Electr. Hybrid Veh. **2007**, 1, 71. [CrossRef]
[65]. Madni, A.M.; Madni, C.C.; Lucero, S.D. Leveraging Digital Twin Technology in Model-Based Systems Engineering. Systems **2019**, 7, 7. [CrossRef]
[66]. Wu, B.; Widanage, W.D.; Yang, S.; Liu, X. Battery digital twins: Perspectives on the fusion of models, data and artificial intelligence for smart battery management systems. Energy AI **2020**, 1, 100016. [CrossRef]
[67]. Microsemi, P.P.G. Gallium Nitride (GaN) Versus Silicon Carbide (SiC) in the High Frequency (RF) and Power Switching Applications. Digi-Key. 2014. [CrossRef]
[68]. Rasool, H.; El Baghdadi, M.; Rauf, A.M.; Zhaksylyk, A.; Hegazy, O. A Rapid Non-Linear Computation Model of Power Loss and Electro Thermal Behaviour of Three-Phase Inverters in EV Drivetrains. In Proceedings of the 2020 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Sorrento, Italy, 24–26 June 2020; pp. 317–323. [CrossRef]
[69]. Keshmiri, N.; Wang, D.; Agrawal, B.; Hou, R.; Emadi, A. Current Status and Future Trends of GaN HEMTs in Electrified Transportation. IEEE Access **2020**, 8, 70553–70571. [CrossRef]
[70]. Sewergin, A.; Wienhausen, A.H.; Oberdieck, K.; De Doncker, R.W. Modular bidirectional full-SiC DC-DC converter for automotive applications. In Proceedings of the 2017 IEEE 12th International Conference on Power Electronics and Drive Systems (PEDS), Honolulu, HI, USA, 12–15 December 2017; pp. 277–281. [CrossRef]
[71]. Rui, R. Power Stage of 48V BSG Inverter. Infineon Appl. Note. 2018. (accessed on 20 March 2023). [CrossRef]
[72]. Liu, Z.; Li, B.; Lee, F.C.; Li, Q. High-Efficiency High-Density Critical Mode Rectifier/Inverter for WBG-Device-Based On-Board Charger. IEEE Trans. Ind. Electron. **2017**, 64, 9114–9123. [CrossRef]
[73]. Rasool, H.; Zhaksylyk, A.; Chakraborty, S.; El Baghdadi, M.; Hegazy, O. Optimal design strategy and electro-thermal modelling of a high-power off-board charger for electric vehicle applications. In Proceedings

of the 2020 Fifteenth International Conference on Ecological Vehicles and Renewable Energies (EVER), Monte-Carlo, Monaco, 10–12 September 2020; pp. 1–8. [CrossRef]
[74]. Chakraborty, S.; Vu, H.-N.; Hasan, M.M.; Tran, D.-D.; El Baghdadi, M.; Hegazy, O. DC-DC Converter Topologies for Electric Vehicles, Plug-in Hybrid Electric Vehicles and Fast Charging Stations: State of the Art and Future Trends. Energies **2019**, 12, 1569. [CrossRef]
[75]. Lu, L.; Han, X.; Li, J.; Hua, J.; Ouyang, M. A review on the key issues for lithium-ion battery management in electric vehicles. J. Power Sources **2013**, 226, 272–288. [CrossRef]
[76]. Fuchs, G.; Lunz, B.; Leuthold, M.; Sauer, D.U. Technology Overview on Electricity Storage. ISEA Aachen Juni. **2012**, 26. (accessed on 20 March 2023). [CrossRef]
[77]. Li, M.; Lu, J.; Chen, Z.; Amine, K. 30 years of lithium-ion batteries. Adv. Mater. **2018**, 30, 1800561. [CrossRef]
[78]. Sun, Y.-K.; Myung, S.-T.; Park, B.-C.; Prakash, J.; Belharouak, I.; Amine, K. High-energy cathode material for long-life and safe lithium batteries. Nat. Mater. **2009**, 8, 320–324. [CrossRef]
[79]. Philippot, M.; Alvarez, G.; Ayerbe, E.; Van Mierlo, J.; Messagie, M. Eco-Efficiency of a Lithium-Ion Battery for Electric Vehicles: Influence of Manufacturing Country and Commodity Prices on GHG Emissions and Costs. Batteries **2019**, 5, 23. [CrossRef]
[80]. Schmuch, R.; Wagner, R.; Hörpel, G.; Placke, T.; Winter, M. Performance and cost of materials for lithium-based rechargeable automotive batteries. Nat. Energy **2018**, 3, 267–278. [CrossRef]
[81]. Xie, J.; Lu, Y.-C. A retrospective on lithium-ion batteries. Nat. Commun. **2020**, 11, 2499. [CrossRef] [PubMed]
[82]. Gopalakrishnan, R.; Goutam, S.; Oliveira, L.M.; Timmermans, J.-M.; Omar, N.; Messagie, M.; Bossche, P.V.D.; van Mierlo, J. A Comprehensive Study on Rechargeable Energy Storage Technologies. J. Electrochem. Energy Convers. Storage **2016**, 13. [CrossRef]
[83]. Berckmans, G.; De Sutter, L.; Marinaro, M.; Smekens, J.; Jaguemont, J.; Wohlfahrt-Mehrens, M.; van Mierlo, J.; Omar, N. Analysis of the effect of applying external mechanical pressure on next generation silicon alloy lithium-ion cells. Electrochim. Acta **2019**, 306, 387–395. [CrossRef]
[84]. Edström, K. BATTERY 2030+. Inventing the Sustainable Batteries of the Future. Research Needs and Future Actions. (accessed on 3 February 2021). [CrossRef]
[85]. Ev, I.G. Outlook to Electric Mobility; International Energy Agency (IEA): Paris, France, 2019. [CrossRef]
[86]. Pasta, M.; Armstrong, D.; Brown, Z.L.; Bu, J.; Castell, M.R.; Chen, P.; Cocks, A.; Corr, S.A.; Cussen, E.J.; Darnbrough, E.; et al. 2020 roadmap on solid-state batteries. J. Phys. Energy **2020**, 2, 032008. [CrossRef]
[87]. Randau, S.; Weber, D.A.; Kötz, O.; Koerver, R.; Braun, P.; Weber, A.; Ivers-Tiffée, E.; Adermann, T.; Kulisch, J.; Zeier, W.G.; et al. Benchmarking the performance of all-solid-state lithium batteries. Nat. Energy **2020**, 5, 259–270. [CrossRef]
[88]. Albertus, P.; Babinec, S.; Litzelman, S.; Newman, A. Status and challenges in enabling the lithium metal electrode for high-energy and low-cost rechargeable batteries. Nat. Energy **2017**, 3, 16–21. [CrossRef]
[89]. Gao, Y.; Rojas, T.; Wang, K.; Liu, S.; Wang, D.; Chen, T.; Wang, H.; Ngo, A.T.; Wang, D. Low-temperature and high-rate-charging lithium metal batteries enabled by an electrochemically active monolayer-regulated interface. Nat. Energy **2020**, 5, 534–542. [CrossRef]
[90]. Forsyth, M.; Porcarelli, L.; Wang, X.; Goujon, N.; Mecerreyes, D. Innovative Electrolytes Based on Ionic Liquids and Polymers for Next-Generation Solid-State Batteries. Acc. Chem. Res. **2019**, 52, 686–694. [CrossRef]
[91]. Chen, X.; Wang, X.; Sun, W.; Jiang, C.; Xie, J.; Wu, Y.; Jin, Q. Integrated interdigital electrode and thermal resistance micro-sensors for electric vehicle battery coolant conductivity high-precision measurement. J. Energy Storage **2023**, 58, 106402. [CrossRef]
[92]. Kerman, K.; Luntz, A.; Viswanathan, V.; Chiang, Y.-M.; Chen, Z. Review—Practical Challenges Hindering the Development of Solid State Li Ion Batteries. J. Electrochem. Soc. **2017**, 164, A1731–A1744. [CrossRef]
[93]. Garbayo, I.; Struzik, M.; Bowman, W.J.; Pfenninger, R.; Stilp, E.; Rupp, J.L. Glass-Type Polyamorphism in Li-Garnet Thin Film Solid State Battery Conductors. Adv. Energy Mater. **2018**, 8, 1702265. [CrossRef]

[94]. Smekens, J.; Gopalakrishnan, R.; Steen, N.V.D.; Omar, N.; Hegazy, O.; Hubin, A.; Van Mierlo, J. Influence of Electrode Density on the Performance of Li-Ion Batteries: Experimental and Simulation Results. Energies **2016**, 9, 104. [CrossRef]

[95]. Krauskopf, T.; Mogwitz, B.; Rosenbach, C.; Zeier, W.G.; Janek, J. Diffusion Limitation of Lithium Metal and Li–Mg Alloy Anodes on LLZO Type Solid Electrolytes as a Function of Temperature and Pressure. Adv. Energy Mater. **2019**, 9, 1902568. [CrossRef]

[96]. Truchot, C.; Dubarry, M.; Liaw, B.Y. State-of-charge estimation and uncertainty for lithium-ion battery strings. Appl. Energy **2014**, 119, 218–227. [CrossRef]

[97]. Li, Y.; Liu, K.; Foley, A.M.; Zülke, A.; Berecibar, M.; Nanini-Maury, E.; Van Mierlo, J.; Hoster, H.E. Data-driven health estimation and lifetime prediction of lithium-ion batteries: A review. Renew. Sustain. Energy Rev. **2019**, 113, 109254. [CrossRef]

[98]. De Sutter, L.; Berckmans, G.; Marinaro, M.; Wohlfahrt-Mehrens, M.; Berecibar, M.; Van Mierlo, J. Mechanical behavior of Silicon-Graphite pouch cells under external compressive load: Implications and opportunities for battery pack design. J. Power Sources **2020**, 451, 227774. [CrossRef]

[99]. Campanella, A.; Döhler, D.; Binder, W.H. Self-healing in supramolecular polymers. Macromol. Rapid Commun. **2018**, 39, 1700739. [CrossRef]

[100]. Wang, C.; Wu, H.; Chen, Z.; McDowell, M.T.; Cui, Y.; Bao, Z. Self-healing chemistry enables the stable operation of silicon microparticle anodes for high-energy lithium-ion batteries. Nat. Chem. **2013**, 5, 1042–1048. [CrossRef] [PubMed]

[101]. Langer, E. Liquid Cooling in Electric Vehicles—What to Know to Keep EVs on the Go By; CPC: Preston, UK, 2019. [CrossRef]

[102]. Habib, S.; Khan, M.M.; Abbas, F.; Tang, H. Assessment of electric vehicles concerning impacts, charging infrastructure with unidirectional and bidirectional chargers, and power flow comparisons. Int. J. Energy Res. **2018**, 42, 3416–3441. [CrossRef]

[103]. Van Mierlo, J.; Berecibar, M.; El Baghdadi, M.; De Cauwer, C.; Messagie, M.; Coosemans, T.; Jacobs, V.A.; Hegazy, O. Beyond the State of the Art of Electric Vehicles: A Fact-Based Paper of the Current and Prospective Electric Vehicle Technologies. World Electr. Veh. J. **2021**, 12, 20. [CrossRef]

[104]. Dusmez, S.; Cook, A.; Khaligh, A. Comprehensive analysis of high quality power converters for level 3 off-board chargers. In Proceedings of the 2011 IEEE Vehicle Power and Propulsion Conference, Chicago, IL, USA, 6–9 September 2011; pp. 1–10. [CrossRef]

[105]. Salgado-Herrera, N.; Anaya-Lara, O.; Campos-Gaona, D.; Medina-Rios, A.; Tapia-Sanchez, R.; Rodriguez-Rodriguez, J. Active Front-End converter applied for the THD reduction in power systems. In Proceedings of the 2018 IEEE Power & Energy Society General Meeting (PESGM), Portland, OR, USA, 5–10 August 2018; pp. 1–5. [CrossRef]

[106]. Kesler, M.; Kisacikoglu, M.C.; Tolbert, L.M. Vehicle-to-Grid Reactive Power Operation Using Plug-In Electric Vehicle Bidirectional Offboard Charger. IEEE Trans. Ind. Electron. **2014**, 61, 6778–6784. [CrossRef]

[107]. Vu, H.-N.; Abdel-Monem, M.; El Baghdadi, M.; Van Mierlo, J.; Hegazy, O. Multi-Objective Optimization of On-Board Chargers Based on State-of-the-Art 650V GaN Power Transistors for the Application of Electric Vehicles. In Proceedings of the 2019 IEEE Vehicle Power and Propulsion Conference (VPPC), Hanoi, Vietnam, 14–17 October 2019; pp. 1–6. [CrossRef]

[108]. Yilmaz, M.; Krein, P.T. Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles. IEEE Trans. Power Electron. **2013**, 28, 2151–2169. [CrossRef]

[109]. Xue, L.; Shen, Z.; Boroyevich, D.; Mattavelli, P.; Diaz, D. Dual Active Bridge-Based Battery Charger for Plug-in Hybrid Electric Vehicle with Charging Current Containing Low Frequency Ripple. IEEE Trans. Power Electron. **2015**, 30, 7299–7307. [CrossRef]

[110]. Li, B.; Lee, F.C.; Li, Q.; Liu, Z. Bi-directional on-board charger architecture and control for achieving ultra-high efficiency with wide battery voltage range. In Proceedings of the 2017 IEEE Applied Power Electronics Conference and Exposition (APEC), Tampa, FL, USA, 26–30 March 2017; pp. 3688–3694. [CrossRef]

[111].Zhaksylyk, A.; Rasool, H.; Geury, T.; El Baghdadi, M.; Hegazy, O. Masterless Control of Parallel Modular Active front-end (AFE) Systems for Vehicles and Stationary Applications. In Proceedings of the 2020 Fifteenth International Conference on Ecological Vehicles and Renewable Energies (EVER), Monte-Carlo, Monaco, 10–12 September 2020; pp. 1–6. [CrossRef]

[112].Blaabjerg, F.; Teodorescu, R.; Liserre, M.; Timbus, A.V. Overview of Control and Grid Synchronization for Distributed Power Generation Systems. IEEE Trans. Ind. Electron. **2006**, 53, 1398–1409. [CrossRef]

[113].Messagie, M.; Mertens, J.; Oliveira, L.; Rangaraju, S.; Sanfelix, J.; Coosemans, T.; Van Mierlo, J.; Macharis, C. The hourly life cycle carbon footprint of electricity generation in Belgium, bringing a temporal resolution in life cycle assessment. Appl. Energy **2014**, 134, 469–476. [CrossRef]

[114].Van Mierlo, J. The world electric vehicle journal, the open access journal for the e-mobility scene. World Electr. Veh. J. **2018**, 9, 1. [CrossRef]

[115].Li, Y.; Messagie, M.; Berecibar, M.; Hegazy, O.; Omar, N.; Van Mierlo, J. The impact of the vehicle-to-grid strategy on lithium-ion battery ageing process. In Proceedings of the 31st International Electric Vehicle Symposium & Exhibition (EVS 31), Kobe, Japan, 1–3 October 2018. [Crossref]

[116].Ahmed, M. (2023). Harvesting Green Power: A Literature Exploration of the Augmented Kalina Cycle with Renewable Energy Sources. Global Mainstream Journal of Innovation, Engineering & Emerging Technology, 2(01), 01-14.

[117].Syed, A.; Crispeels, T.; Jahir Roncancio Marin, J.; Cardellini, G.; De Cauwer, C.; Coosemans, T.; Van Mierlo, J.; Messagie, M. A Novel Method to Value the EV-Fleet's Grid Balancing Capacity. In Proceedings of the 33th International Electric Vehicle Symposium and Exhibition (EVS 2020), Portland, OR, USA, 14–17 June 2020; pp. 14–17. [CrossRef]

[118].De Cauwer, C.; Van Kriekinge, G.; Van Mierlo, J.; Coosemans, T.; Messagie, M. Integration of Vehicle-to-Grid in Local Energy Systems: Concepts and Specific Requirements. In Proceedings of the 33th International Electric Vehicle Symposium and Exhibition (EVS 2020), Portland, OR, USA, 14–17 June 2020; pp. 14–17. [CrossRef]

[119].Hooftman, N.; Messagie, M.; Van Mierlo, J.; Coosemans, T. The Paris Agreement and Zero-Emission Vehicles in Europe: Scenarios for the Road towards a Decarbonised Passenger Car Fleet. In Towards User-Centric Transport in Europe 2: Enablers of Inclusive, Seamless and Sustainable Mobility; Springer, 2020; pp. 151–168. [CrossRef]

[120].Messagie, M.; Coosemans, T.; Van Mierlo, J. The Need for Uncertainty Propagation in Life Cycle Assessment of Vehicle Technologies. In Towards User-Centric Transport in Europe 2: Enablers of Inclusive, Seamless and Sustainable Mobility; IEEE Xplorer: 2019; pp. 1–7. [CrossRef]

[121].Narayanan, S.; Chaniotakis, E.; Antoniou, C. Shared autonomous vehicle services: A comprehensive review. Transp. Res. Part C Emerg. Technol. **2020**, 111, 255–293. [CrossRef]

[122].Loeb, B.; Kockelman, K.M. Fleet performance and cost evaluation of a shared autonomous electric vehicle (SEAVS) fleet: A case study for Austin, Texas. Transp. Res. Part A Policy Pract. **2019**, 121, 374–385. [CrossRef]

[123].Haas, H. Wireless Data from Every Light Bulb. (accessed on 13 February 2023). [CrossRef]

[124].Golbabaei, F.; Yigitcanlar, T.; Bunker, J. The role of shared autonomous vehicle systems in delivering smart urban mobility: A systematic review of the literature. Int. J. Sustain. Transp. **2020**, 15, 731–748. [CrossRef]

[125].Maurer, M.; Gerdes, J.C.; Lenz, B.; Winner, H. Autonomous Driving: Technical, Legal and Social Aspects; Springer Nature: Berlin/Heidelberg, Germany, 2016. [CrossRef]

[126].Fagnant, D.J.; Kockelman, K. Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. Transp. Res. Part A Policy Pract. **2015**, 77, 167–181. [CrossRef]

[127].Cohen, T.; Cavoli, C. Automated vehicles: Exploring possible consequences of government (non)intervention for congestion and accessibility. Transp. Rev. **2019**, 39, 129–151. [CrossRef]

[128].Chen, T.D.; Kockelman, K.M.; Hanna, J.P. Operations of a shared, autonomous, electric vehicle fleet: Implications of vehicle & charging infrastructure decisions. Transp. Res. Part A Policy Pract. **2016**, 94, 243–254. [CrossRef]

[129].Iacobucci, R.; McLellan, B.; Tezuka, T. Modeling shared autonomous electric vehicles: Potential for transport and power grid integration. Energy **2018**, 158, 148–163. [CrossRef]

[130].Tan, K.M.; Ramachandaramurthy, V.K.; Yong, J.Y. Integration of electric vehicles in smart grid: A review on vehicle to grid technologies and optimization techniques. Renew. Sustain. Energy Rev. **2016**, 53, 720–732. [CrossRef]

[131].Rangaraju, S. Environmental Performance of Battery Electric Vehicles: Implications for Future Integrated Electricity and Transport System. Ph.D. Thesis, 2018. [CrossRef]

[132].Trübswetter, N.; Bengler, K. Why should I use ADAS? Advanced driver assistance systems and the elderly: Knowledge, experience and usage barriers. In Driving Assesment Conference; University of Iowa: Iowa, IA, USA, 2013; Volume 7. [CrossRef]

[133].Eichelberger, A.H.; McCartt, A.T. Toyota drivers' experiences with dynamic radar cruise control, pre-collision system, and lane-keeping assist. J. Saf. Res. **2016**, 56, 67–73. [CrossRef] [PubMed]

[134].Hubele, N.; Kennedy, K. Forward collision warning system impact. Traffic Inj. Prev. **2018**, 19, S78–S83. [CrossRef] [PubMed]

[135].Patra, S.; Veelaert, P.; Calafate, C.T.; Cano, J.-C.; Zamora, W.; Manzoni, P.; González, F. A Forward Collision Warning System for Smartphones Using Image Processing and V2V Communication. Sensors **2018**, 18, 2672. [CrossRef]

[136].Motamedidehkordi, N.; Amini, S.; Hoffmann, S.; Busch, F.; Fitriyanti, M.R. Modeling tactical lane-change behavior for automated vehicles: A supervised machine learning approach. In Proceedings of the 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), Naples, Italy, 26–28 June 2017; pp. 268–273. [CrossRef]

[137].Yan, Z.; Yang, K.; Wang, Z.; Yang, B.; Kaizuka, T.; Nakano, K. Intention-Based Lane Changing and Lane Keeping Haptic Guidance Steering System. IEEE Trans. Intell. Veh. **2020**, 6, 622–633. [CrossRef]

[138].Katzourakis, D.I.; Lazic, N.; Olsson, C.; Lidberg, M.R. Driver Steering Override for Lane-Keeping Aid Using Computer-Aided Engineering. IEEE/ASME Trans. Mechatron. **2015**, 20, 1543–1552. [CrossRef]

[139].Shen, D.; Yi, Q.; Li, L.; Tian, R.; Chien, S.; Chen, Y.; Sherony, R. Test Scenarios Development and Data Collection Methods for the Evaluation of Vehicle Road Departure Prevention Systems. IEEE Trans. Intell. Veh. **2019**, 4, 337–352. [CrossRef]

[140].Sternlund, S.; Strandroth, J.; Rizzi, M.; Lie, A.; Tingvall, C. The effectiveness of lane departure warning systems—A reduction in real-world passenger car injury crashes. Traffic Inj. Prev. **2017**, 18, 225–229. [CrossRef]

[141].Abdullahi, A.; Akkaya, S. Adaptive cruise control: A model reference adaptive control approach. In Proceedings of the 2020 24th International Conference on System Theory, Control and Computing (ICSTCC), Sinaia, Romania, 8–10 October 2020; pp. 904–908. [CrossRef]

[142].Li, Y.; Li, Z.; Wang, H.; Wang, W.; Xing, L. Evaluating the safety impact of adaptive cruise control in traffic oscillations on freeways. Accid. Anal. Prev. **2017**, 104, 137–145. [CrossRef] [PubMed]

[143].Plessen, M.G.; Bernardini, D.; Esen, H.; Bemporad, A. Spatial-Based Predictive Control and Geometric Corridor Planning for Adaptive Cruise Control Coupled with Obstacle Avoidance. IEEE Trans. Control Syst. Technol. **2017**, 26, 38–50. [CrossRef]

[144].Hu, J.; Xu, L.; He, X.; Meng, W. Abnormal Driving Detection Based on Normalized Driving Behavior. IEEE Trans. Veh. Technol. **2017**, 66, 6645–6652. [CrossRef]

[145].Adochiei, I.-R.; Stirbu, O.-I.; Adochiei, N.-I.; Pericle-Gabriel, M.; Larco, C.-M.; Mustata, S.-M.; Costin, D. Drivers' drowsiness detection and warning systems for critical infrastructures. In Proceedings of the 2020 International Conference on e-Health and Bioengineering (EHB), Iasi, Romania, 29–30 October 2020; pp. 1–4. [CrossRef]

[146]. Saito, Y.; Itoh, M.; Inagaki, T. Driver Assistance System with a Dual Control Scheme: Effectiveness of Identifying Driver Drowsiness and Preventing Lane Departure Accidents. IEEE Trans. Human Mach. Syst. **2016**, 46, 660–671. [CrossRef]
[147]. Yin, J.-L.; Chen, B.-H.; Lai, K.-H.R.; Li, Y. Automatic Dangerous Driving Intensity Analysis for Advanced Driver Assistance Systems from Multimodal Driving Signals. IEEE Sens. J. **2017**, 18, 4785–4794. [CrossRef]
[148]. Chen, Y.; Peng, H.; Grizzle, J. Obstacle Avoidance for Low-Speed Autonomous Vehicles with Barrier Function. IEEE Trans. Control Syst. Technol. **2017**, 26, 194–206. [CrossRef]
[149]. Funke, J.; Brown, M.; Erlien, S.M.; Gerdes, J.C. Collision Avoidance and Stabilization for Autonomous Vehicles in Emergency Scenarios. IEEE Trans. Control Syst. Technol. **2016**, 25, 1204–1216. [CrossRef]
[150]. Viriyasitavat, W.; Tonguz, O.K. Priority management of emergency vehicles at intersections using self-organized traffic control. In Proceedings of the 2012 IEEE Vehicular Technology Conference (VTC Fall), Quebec City, QC, Canada, 3–6 September 2012; pp. 1–4. [CrossRef]