African Journal of Advanced Pure and Applied Sciences (AJAPAS)
Online ISSN: 2957-644X
Volume 3, Issue 5, 2024
Page No: 1-11
Website: [*https://aaasjournals.com/index.php/ajapas/index*](https://aaasjournals.com/index.php/ajapas/index)

ISI 2024: 0.877 **SJIFactor 2024: 6.752** **معامل التأثير العربي: 1.62**

Special issue: First International Conference on Technical Science (FICTS-2024), Sabha, Libya

Challenges and Novel Strategy for Electric Vehicle Integration in Power System - Case Study Libya

Ibrahim Imbayah [1*], Yasser F. Nassar [2], Yuosef Adraider [3], Abdulgader Alsharif [4],
Hala El-Khozondare [5], Abdussalam Ali Ahmed [6]

[1] Department of Energy Engineering, College of Renewable Energy, Tajoura, Libya
[2] Center for Renewable Energy and Sustainable Development Research and Studies, Libya
[3] Department of Energy Engineering, College of Renewable Energy, Tajoura, Libya
[4] Department of Electrical & Electronics Engineering, College of Technical Science, Sabha-Libya
[5] Department of Electric Engineering and Smart Systems, Faculty of the Islamic University of Gaza Gaza, Palestine
[6] Mechanical Engineering Department, Bani Waleed University, Bani Waleed, Libya,

التحديات والاستراتيجية الجديدة لدمج المركبات الكهربائية في نظام الطاقة – دراسة حالة ليبيا

إبراهيم امبية [1*]، ياسر فتحي نصار[2]، يوسف عبدالله دريدر[3]، عبد القادر الشريف [4]، هالة جار الله الخزندار[5]،
عبد السلام علي أحمد[6]

[1] قسم هندسة الطاقة، كلية الطاقة المتجددة، تاجوراء، ليبيا.
[2] مركز بحوث ودراسات الطاقة المتجددة والتنمية المستدامة، برك الشاطئ، ليبيا.
[3] قسم هندسة الطاقة، كلية الطاقة المتجددة، تاجوراء، ليبيا.
[4] قسم الهندسة الكهربائية والإلكترونيات. كلية العلوم التقنية، سبها، ليبيا.
[5] قسم الهندسة الكهربائية والأنظمة الذكية ، كلية الهندسة الكهربائية والإلكترونيات، جامعة غزة، فلسطين.
[6] قسم الهندسة الميكانيكية، جامعة بني وليد، بني وليد، ليبيا.

[*]Corresponding author: ibrahim.alzayani@gmail.com

Received: May 01, 2024	Accepted: October 08, 2024	Published: November 12, 2024

Abstract:
this paper investigates the challenges of Electric Vehicle (EV) integration in the grid system of Libya. To examine the effects of various EV penetration scenarios on Libya's generation a study is carried out. Increased peak demand, two-way power flows from vehicle-to-grid technology, and the requirement for further investment in charging infrastructure are among the major issues that have been identified. An innovative technique is suggested. Coordinated charging and vehicle-to-grid control algorithms are used to provide Libyan electric grid services and move EV load to off-peak times. The results guide other developing countries in bolstering their power infrastructure and achieving sustainable transportation goals.

Keywords: Electric Vehicle, Charging Infrastructure, Charging Technologies, Libya.

الملخص
لا تزل ليبيا تفتقر إلى شبكة شحن لسيارات الكهربائية، ومعدل استخدام السيارات الكهربائية في البلاد منخفضا جدا. تقدم هذه المقالة تحديات دمج المركبات الكهربائية في نظام الشبكة الكهربائية في ليبيا. ولدراسة تأثيرات مختلف سيناريوهات تغلغل المركبات الكهربائية على توليد الكهرباء في ليبيا. من بين القضايا الرئيسية التي تم تحديدها زيادة الطلب في أوقات الذروة، وتدفق الطاقة في اتجاهين من تكنولوجيا المركبات إلى الشبكة،

ومتطلبات المزيد من الاستثمار في البنية التحتية للشحن. تم اقتراح تقنية مبتكرة. تُستخدم خوارزميات الشحن المنسق وخوارزميات التحكم في تحويل المركبات إلى الشبكة لتوفير خدمات الشبكة الكهربائية الليبية ونقل أحمال المركبات الكهربائية إلى أوقات خارج أوقات الذروة. تقدم النتائج إرشادات للبلدان النامية الأخرى حول كيفية تعزيز البنية التحتية للطاقة وتحقيق أهداف النقل المستدام.

الكلمات المفتاحية: السيارة الكهربائية، البنية التحتية للشحن، تقنيات الشحن، ليبيا.

Introduction

Libya is a country of approximately 1,759,540 square km. It is connected by a highway network of 83,200 km, of which 47,590 km are paved roads. Additionally, over 140 airports and airstrips are spread across various Libyan towns. With an estimated 5,483,760 cars on the road, the transportation industry is thought to use the most fuel, roughly 5,545,000 tons annually. Every year, the transportation industry uses roughly 17,262 Terajoules (TJ) of electrical energy. This industry is predicted to emit 18,246 million tons of CO_2 annually.

Libya's economy was based on the production of oil and natural gas, so it is difficult to alter its structure. With the right investment and training, the state can use sustainable, renewable energy to expand its existing revenue base. Libya can fully satisfy its electricity requirements, power the general grid, charge EVs, and export a sizeable amount of electricity to its neighbors in southern Europe by utilizing the renewable energy sources that are available in this oil-rich country. Libya has the potential to become a global leader in renewable energy [1-10].

It has a very high daily solar radiation rate, which in the southern area is about 8.1 kWh/m^2/day and is roughly 7.1 kWh/m^2/day in the flat coastal plain. Libya could produce more than five times as much PV system if it used a PV system to harvest just 0.1% of the Earth's mass, according to a study that was published in the Journal of Renewable Energy. If Libya generates even 0.1% of the Earth's bulk using solar energy, Libyan solar resource map.as shown in Figure 1 [11].

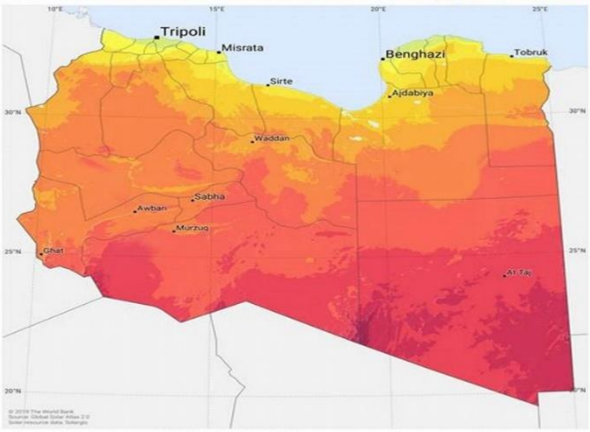

Figure 1: Libyan solar resource map.

Due to the benefits of EV integration, several researchers paid attention to overcoming power and environmental limitations. Two major obstacles still exist for the electric car (EV) market in Libya: cost and range. The latter is thought to be the key development for widespread EV usage. Integrating the powertrain is one strategy to lower expenses and improve system performance. pointed out that the expense difference (of about €10,000) between a combustion car and an electric car is still substantial. However, is clear that this trend is very intriguing if you consider the number of consumers who are contemplating buying EVs. The introduction of new semiconductor technologies will raise the EV system's total efficiency [12].

According to the Global EV, hundreds of thousands of new electric cars (EVs), ranging from plug-in hybrids to totally electric, will enter service in the upcoming years, increasing the global EV fleet's existing size of over 2 million. When combined with a portfolio of low-carbon power generation, the electrification of transportation can have positive effects on the environment, human health, and the economy [13]. To combat rising air pollution levels, many countries are quickly expanding the number of electric vehicles (EVs) in their transportation fleets. Among non-fossil fuel-based transportation options, electric vehicles stand out in terms of operating costs and the capacity to support the utility power infrastructure.

Electric cars are dispersed energy storage systems that can provide power to the local distribution grid. As electric vehicles gain popularity, the market for these vehicles must expand quickly to meet consumer expectations, achieve global targets for reducing greenhouse gas emissions, and improve urban air quality. But as electric vehicles age, an increasing number of them pose a significant waste management challenge for recyclers. However, since manufacturers need to have access to vital materials and components for crucial parts used in the assembly of electric vehicles, spent batteries can potentially offer a possibility. Recycled lithium-ion batteries from electric cars are one possible important secondary supply of materials. The future development in the various ways that lithium-ion batteries for electric cars are currently recycled and utilized again [14].

One way to lower peak electricity demand is to use renewable energy sources (RES) and electric vehicles (EVs). The most challenging of these domains is that of the vehicle to grid or grid to the vehicle interactions, especially when it comes to EV use. Future generations of electric vehicle (EV) transportation will be developed with the integration of renewable energy, which will improve environmental sustainability and lower CO2 emissions. This study aims to show how Smart Buildings (SB) interact with energy storage technologies and electric vehicles (EVs) for grid load shifting, peak cutting, and reduction. Due to their enhanced performance, efficiency, and capacity to reduce the effects of carbon emissions and global warming, electric vehicles (EVs) have drawn significant attention in the automotive sectors. The use of EVs has several possible advantages, including greater reliance on renewable energy sources, less reliance on fossil fuel-based power plants, and the ability to store energy. Even though EVs can greatly reduce global carbon emissions, the power balance must be kept during peak charging times. As a result, it requires a thorough analysis of the effects of high levels of electric car penetration in utility grids.

When EVs should add power to the grid is decided by the market operator and is based on the grid's loading, or how strongly or weakly it is loaded. In a similar vein, the operating modes mentioned earlier have an impact on energy rates. Grid-to-vehicle (G2V) is the inferred mode for consumers, and vehicle-to-grid (V2G) is the implied manner for prosumers. EV behaves as an electrical load in G2V mode and as an injecting source in V2G mode. Each EV tire is powered by an electric motor (EM), which simplifies system regulation and stabilizes moments. The term "V2G" describes how aggregators control utility loads' energy use by using communication between the power grid and consumers. Vehicle-to-vehicle (V2V), vehicle-to-home (V2H), and vehicle-to-grid (V2G) are examples of emerging electric vehicle (EV) technology. The sign (V2H) denotes a service exchange between the battery and the EV household outlet [15].

In such circumstances, EV batteries store energy and offer RES and home appliances backup power. V2V stands for vehicle-to-vehicle power exchange. V2G trades energy to the power grid via management, utilizing the energy generated by the local EV communities Shown in Figure 2 Interactions between grids and vehicles [16].

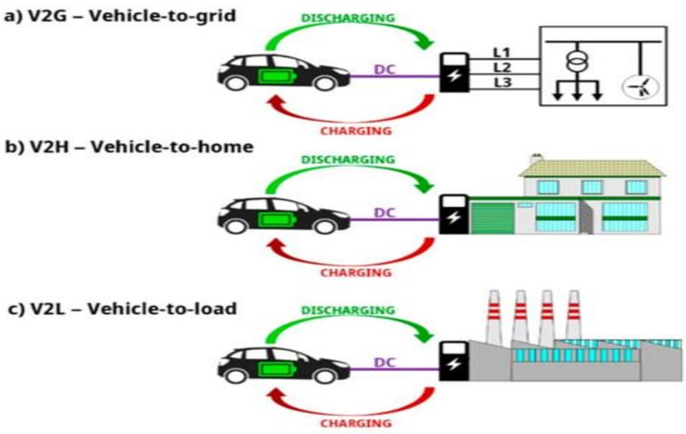

Figure 2: Interactions between grids and vehicles [15].

The study examines the effects of widespread EV adoption on low voltage distribution while taking into account charging duration, method, and characteristics [17]. When talking about power consumption, voltage profile, power quality, and EV integration into the utility system, many charging scenarios are considered. and system sufficiency to investigate the impact, a lookup-table-based EV charging method is suggested along with a comprehensive integration. High-level EV charging has been observed. Draining affects the voltage of the line and the bus. The results show that the residential grid voltage sag increases by 1.96% to 1.521%, 2.21%, 1.96% to 1.77%, and 1.93%, respectively, when four different EV-charging profiles are examined. The results of this study can be used to build EV charging and discharging systems that have the least negative effects on bus voltage and line current [18].

Fast charging stations are necessary for electric vehicles (EVs), which puts high-point loads on the LV infrastructure. The network supply may be disrupted as a consequence, and there may be problems with low voltage and power quality. strategy or control over the positioning and design of charging stations could have long-term disruptive effects and raise customer energy costs. Developing a charging plan that will improve network performance is necessary. Frequency and voltage control are two potential advantages of EVs for the device. Models for calculating the impact of EVs on the price of marketplaces in Libya must be created. In this field, research is crucial. The development of the EV charging plan and this analysis both call for tight cooperation between energy consumers and producers, which wasn't always the case with the use of fossil fuels. The shortterm effects of EVs on the network are not anticipated to be significant, but they will become more common as EV production rises. To ensure the seamless integration of EVs into the existing LV and MV networks, electric grid models and policies must be crucial [19].

The authors realize that the spread of EVs in the current situation of the dilapidated generation and distribution system is unhealthy, due to the low efficiency of the system, which will undoubtedly be much less than the efficiency of a gasoline engine vehicles, but here in this research, we lay the infrastructure for the transition from traditional generation to renewable, clean and sustainable stage.

Libya has abundant solar resources that could be used to generate electricity. At more than 5 kWh/m2/day on average, it receives some of the greatest sun irradiation levels in the world. This makes using solar energy a very sensible choice. Solar power facilities could assist Libya in sustainably supplying its increasing electricity needs. Libya's economy and population are expanding, increasing the country's energy requirements. Solar power can lessen dependency on imported fuels and augment current fossil fuel generation. Given that Libya's needs are best met during the day when the sun is at its brightest, solar energy makes sense. This aligns daily consumption patterns with the availability of solar electricity. It may assist in avoiding or minimizing the requirement for pricey peaker plants.

Libya's huge desert lands could be utilized for the construction of large utility-scale solar installations. The national grid would receive large amounts of renewable electricity from this. Solar energy has the potential to eventually replace certain fossil fuel power, freeing up additional gas and oil for export. Expanding earnings from energy exports and diversifying energy sources, would strengthen Libya's economy. Shown in Figure 3 planning for a solar project in Libya.

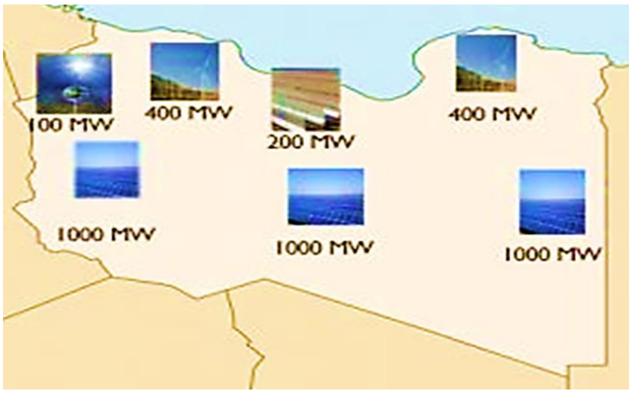

Figure 3: Planning for a solar project in Libya.

So in summary, expanding Libya's usage of solar energy through utility-scale facilities has a strong chance of helping the country fulfill its expanding electricity needs in a sustainable manner that takes advantage of its abundance of solar resources. In the long run, it might improve economic prospects and energy security.

A. Main contribution

The contribution to the knowledge provided in this article is investigating the limitations of integrating EV under LV in northern African countries along with presenting integration forms considering Libya as a case study.

B. Outline

The remaining sections in the article are organized as follows: the EV charging station types are placed in Section 2. Section 3 discusses the charging technologies and the integration topologies. Section 4 presents the operation modes of charging EVs. The charging infrastructure for charging and discharging the EVs is positioned in Section 5. Finally, a summary of the conclusion followed by the references closing the article remaining.

Electric Vehicle Charging Station Type

Commercial debut. In contrast to battery and fuel cell electric vehicles (EVs), modern hybrid EVs also have an internal combustion engine. Because these automobiles' batteries will need to be able to store a lot of energy in addition to being able to charge an electric load. Implementation of Enhanced Charging Strategies is used to integrate more electric vehicles, the peak hour for load in a residential neighborhood coincides with the arrival of many EVs at their homes, according to the usual traffic patterns.

Therefore, by that point, existing EVs will be hooked. Future projections indicate a sharp increase in the usage of electric vehicles (EVs) as a response to the shortage of fossil fuels and the environmental issues brought on by their extensive use. Shown in Figure 4. Three key types of electric vehicles are now being readied for market introduction: fuel cell EVs, hybrid EVs, and complete EVs. While modern hybrid EVs also contain an internal combustion engine, battery, and fuel cell EVs can only be powered by electricity. Because these cars will demand the usage of batteries with huge electric load charging capacity and high energy storage capacity [20].

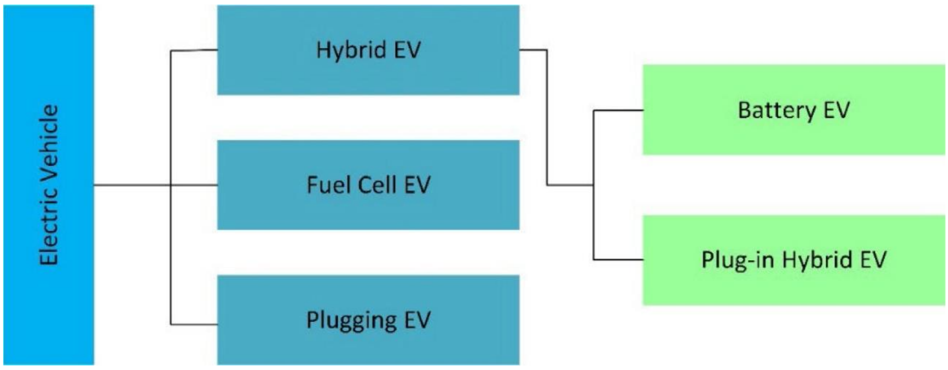

Figure 4: Three key types of electric vehicles [11].

Electric Vehicle Charging Technologies

Although EV supporters have spent decades addressing various issues, EV charging control solutions that can have a large impact on the power network and benefit EV owners are still being developed. As a result, much effort has been put into achieving ideal charging management. For the provision of ancillary services, various charging control schemes based on vehicle-to-grid (V2G) technology have been proposed. Research has been done on PHEV (plug-in hybrid electric vehicle) charging techniques. EV aggregator, a grid-wide agent for communication and control [21].

Table 1: Integration Topologies.

Topologies	Features	Ref
Vehicle-to-grid (V2G)	Exchanging power between the EV and grid	[22]
Vehicle-to-infrastructure (V2I)	Exchanging power between the EV and traffic light	[23]
Vehicle-to-home (V2H)	Exchanging power between the EV and home devices	[24]
Vehicle-to-building (V2B)	Exchanging power between the EV and the building	[25]
Vehicle-to-vehicle (V2V)	Exchanging power between the EV and EV	[26]

It is projected that a significant increase in the use of electric vehicles (EVs) will address the depletion of fossil fuels and the environmental problems associated with their widespread use. As illustrated in Figure. 5, there are a few global standards that must be taken into account while adopting the different levels, methods, and systems for EV charging.

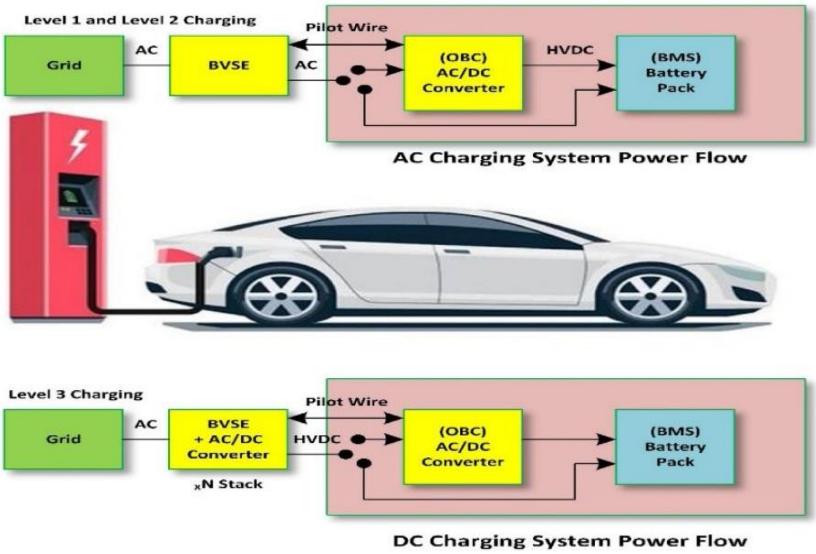

Figure 5: Charging techniques for various stages [11].

A viable method for utilizing electric vehicles (EVs) extensively in power grids is centralized charging based on battery swapping. The most notable aspect of this technique is that EV batteries may be switched out quickly, charged at low electricity costs or during off-peak hours, and scheduled at any battery swap station. By taking into account the best charging priority and location (station or bus node in a power system) based on the location, this is a revolutionary centralized charging approach for EVs under the battery swapping scenario.

The development of EV charging control strategies that can affect the power network and assist EV owners is still ongoing, even though EV enthusiasts have spent decades addressing a variety of issues. As a result, a lot of effort has been put into achieving ideal charging management. For the provision of ancillary services, various charging control schemes based on vehicle-to-grid (V2G) technology have been proposed. EV aggregators, a communication and control agent between the grids, have been studied for plug-in hybrid electric car charging techniques. To avoid an overload problem caused by EV charging, the maximum power consumption should be established for each period. A new peak demand could form if all EV owners have a preference for the precise moment when the cost of energy is lowest. Therefore, additional EVs should be permitted to connect to the distribution system once the charging load of the current EVs has reached a predetermined limit. The daily home load curve and overall cost of electricity are impacted by the EV charging priority that chooses the order of [27]. The battery electric vehicles (BEVS) adoption is increasing, which may cause serious grid problems but also promote flexibility. This clarifies the difficulties and opportunities of integrating (BEVS) into power systems. For use cases, six low-voltage grids for both urban and rural areas were used to develop three charging options. The charging method has a big impact on grid problems, especially in rural areas, where many automobiles charge overnight at home. Purely market-driven methods may result in large load peaks, which then cause overloading of the transformer and the lines, or even a catastrophe [28].

Electric Vehicle Operation Modes

Electric vehicles are gaining popularity as an answer to energy and environmental issues. Plugin electric vehicles (EVs) allow them to be charged and discharged into the grid. This is because vehicles emit less carbon dioxide and offer other benefits to the power grid.

PEVs use electricity from the grid as generators during the discharging phase when they are not in use for transportation, or as batteries during the charging phase for future use. The vehicle-to-home (V2H) method of operation refers to this discharge phase [29]. There are currently a lot of ways to charge and manage batteries. Inverters convert AC power into DC so that electric automobiles can charge their batteries. There are several methods for transferring charges, such as battery switching, conductive charging, and inductive charging. Figure.6 categorizes two types of conductive charging: overnight charging and pinto graph charging (total and bottom-up) [31].

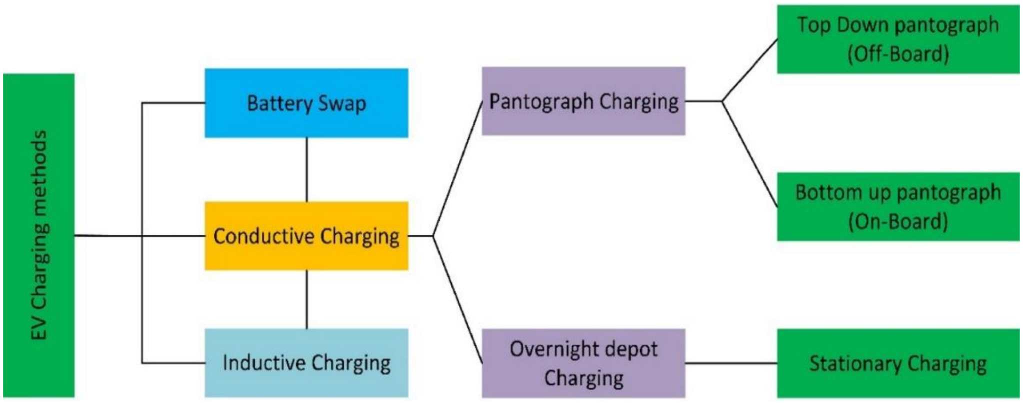

Figure 6: EV Operation modes.

Mathematical equations for controlling the operation of charging and discharging. The EV is charging EVs at home to continue driving and reduce the anxiety of drivers. To create a model for analyzing an electric vehicle's range using cycles of motion, the acceleration values (a) required to compute the dynamic force must first be found for each segment of the cycle time V(t). The vehicle's acceleration value is the speed derivative concerning time. This can be estimated by Eq. (1).

$$a=dV(t)dt,\ \mathrm{m/s^2} \qquad (1)$$

The dynamic force (Fd) is computed by multiplying the acceleration by the electric vehicle's mass and accounting for the rotating parts' coefficient of inertia by Eq. (2).

$$Fd=(1+\gamma)\cdot m\cdot a,\ \mathrm{N} \qquad (2)$$

Where the rotating pieces' coefficient of inertia is expressed as $\gamma = 0.1$. The rolling force (Froll) must be added to the total air resistance force (Fair) to determine the specific resistance force (Fc) for each moment of movement of an electric vehicle by Eq. (3).

$$Fc=Fair+Froll,\ \mathrm{N} \qquad (3)$$

The electric vehicle's frontal size and movement speed increase with the full force of air resistance; therefore, the body's streamlined appearance is important in Eq. (4).

$$Fair=S\cdot k\cdot V^2,\ \mathrm{N} \qquad (4)$$

Where k is the streamlining coefficient, defined as N·s2/m4, and S is the electric vehicle's frontal area, measured as m2 in Eq. (5).

$$k=0.5\cdot C_X\cdot \rho_{air} \qquad (5)$$

Where CX is the coefficient of aerodynamic air resistance; for the body of a typical electric car, we will pick CX = 0.35 N·s2/m·kg. Where ρair = 1.225 kg/m3—air density When we change the values of the parameters, we get in Eq. (5).

$$S=0.9\cdot h\cdot b=0.9\times 1705\times 1585\times 10^{-6}=2.43\ \mathrm{m}^2 \qquad (6)$$

The rolling force has the following value in Eq. (7).

$$Froll=m\cdot g\cdot f_{roll,}\ \mathrm{N} \qquad (7)$$

Where m is the electric vehicle's mass in kilograms; g is the free-fall acceleration; and $Froll$ is the wheel's rolling friction coefficient, which is equal to 0.015 for roads with asphalt concrete pavement. The acceleration and resistance to movement should be set by the force applied to the wheel while it is in the traction mode [39]. Refers to EV power demand, the capacity of the EV battery which is found in the EV data sheet (from the manufacturer), the maximum and minimum State of charge of the EV battery, and the charging duration time in the charge station as mathematically expressed. Besides, the consideration time during the arrival moment is indicated as the departure time [30].

The Energy PLAN, a computer model for energy systems analysis of the main energy systems that run hourly, served as the foundation for the evaluations of several charging regulatory methods for electric vehicles. 2020, 2030, and 2050 were chosen as the target years for the calculations. The Energy PLAN included four different charging models: dumb charge, flexible demand, smart charge, and smart charge with vehicle-to-grid. Two distinct charging models were chosen for each year. Charging policies are based on three different tariff models, each of which uses different pricing for power. The utility's perspective on the eventual integration of EVs (such as transformer aging, line overloading, etc.).

The detrimental effects of EVs on power distribution systems are one of the main barriers to their successful integration into the present transportation systems. The distribution system will be overloaded if EVs are charged at the same time as peak load times. Additionally, with a 60% EV penetration level, augmentation investment costs might increase to 15%, and energy losses could reach 40% [31].

Electric Vehicle Charging Infrastructure

Having a good enough infrastructure to recharge cars will help EV adoption [32]. Technology and practicality will help electric vehicle adoption. More individuals driving electric automobiles encourages environmentally sustainable mobility and lessens our reliance on fossil fuels. Apart from electric vehicles, there will be an increase in emissions from other power-producing facilities like conventional power plants. The utilization of renewable energy sources has to increase significantly to meet the rising energy demand. The rise in electric car sales should align with the implementation of renewable energy generation. An all-encompassing infrastructure for charging electric vehicles consists of power, control, and communication systems as well as charging ports and connectors that follow various standards [33].

The following is a list of the subjects, difficulties, and most recent technological advancements in the infrastructure of electric vehicle charging stations, as shown in Figure 7. The following variables, problems, and recent technological developments are relevant to the infrastructure of electric vehicles and charging stations [34], [35].

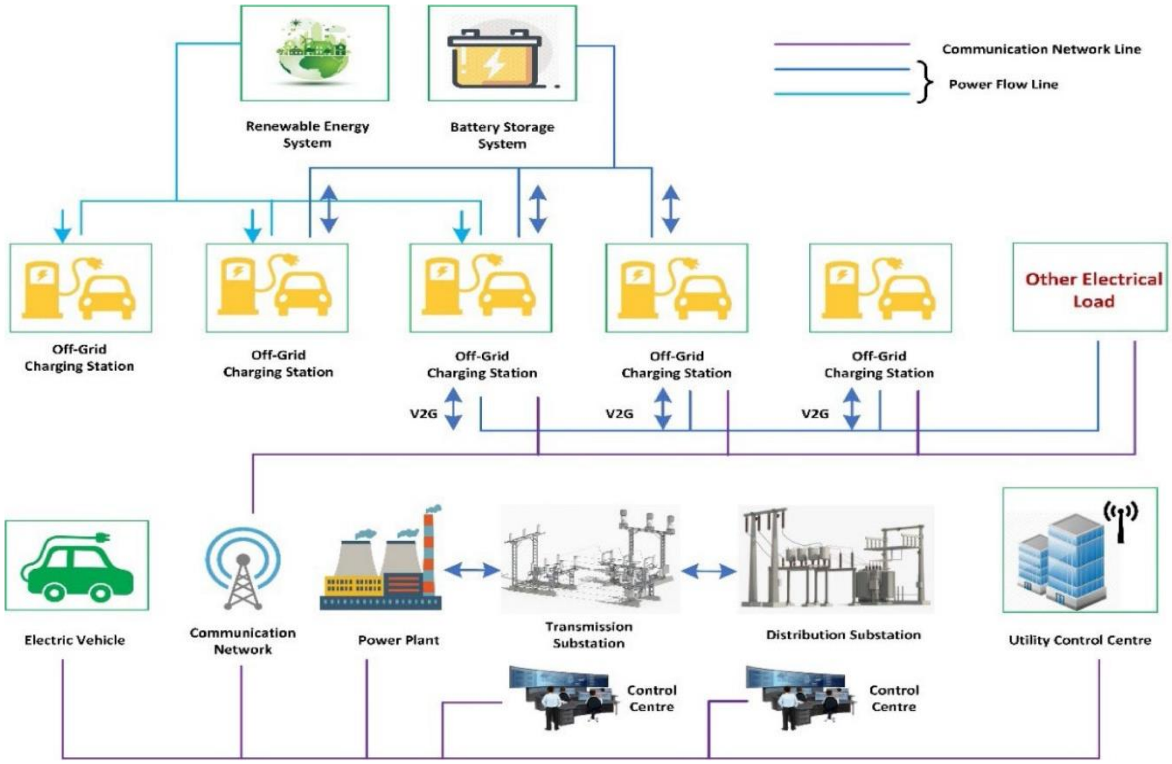

Figure 7: Electric vehicle charging infrastructure.

Users eagerly await a sufficient infrastructure for charging that ensures minimal to no delays in the charging process. Consequently, until there are enough electric vehicles on the road, investors are deferring spending money on charging infrastructure [36]. On the best kind of charging for EV charging stations—rapid or smart—stakeholders cannot agree. The government must take action to resolve these problems. Another significant barrier to the widespread use of EVs is the high cost of batteries that can store energy for an extended amount of time [37], [38].

Future Direction

In Libya, like in many other countries, the adoption of electric vehicles (EVs) faces several challenges. However, there are also opportunities and future directions that can help overcome these challenges. The listed below are some of the key aspects to be taken into consideration among scholars. Future direction research points as shown in Table 2.

Table 2. Future Direction Research Points.

Challenges	Explanations
Charging Infrastructure	There is no infrastructure for charging electric vehicles (EVs) is a significant barrier to their broad adoption. To promote EVs in Libya, a significant investment needs to be made in establishing a comprehensive network of charging stations. Governments and private companies should collaborate to develop charging infrastructure along major highways, urban areas, and public spaces.
Affordability and Availability	Making EVs affordable and widely available is crucial for their adoption. Libyan Government can introduce incentives such as tax breaks, subsidies, and reduced import duties to encourage the purchase of EVs.
Education and Awareness	Raising awareness among the Libyan people about the benefits of EVs is crucial. Through awareness efforts, the advantages of electric vehicles (EVs) for economics,

	ecology, and technology should be highlighted. Workshops, conferences, and seminars are further options for dispelling EV myths and misconceptions.
Local Manufacturing	Encouraging local manufacturing of EVs and their components can boost economic growth and create job opportunities. Libyan governments can provide incentives to attract foreign investment and establish local manufacturing plants. This can help reduce import dependency and stimulate the growth of the EV industry within Libya.
Integration with Renewable Energy	Libyan has abundant renewable energy resources, particularly solar power. Integrating EV charging infrastructure with renewable energy generation can create a sustainable ecosystem. This synergy can reduce greenhouse gas emissions, enhance energy security, and contribute to the growth of both the EV and renewable energy sectors.
Public Transportation and Fleet Electrification	Focusing on electrifying public transportation and vehicles can have a significant impact on reducing emissions and promoting EV adoption. The Libyan government can prioritize the electrification of buses, taxis, and delivery fleets. Implementing supportive policies and providing financial incentives can encourage fleet operators to transition to EVs.
Research and Development	The investment in research and development in Libya is necessary to address specific challenges and tailor EV solutions to the regional context. Collaborative efforts between academics, private companies, and Libyan governments can drive innovation in areas such as battery technology, charging infrastructure, and grid integration with EVs.

Conclusions

Libya is looking into the usage of electric vehicles, but it has problems with its outdated transmission system and lack of facilities for charging them. Unregulated EV charging has the potential to worsen current grid problems. Three layers of a hierarchical control approach primary control at the charging station, secondary control at the distribution level, and tertiary control at the transmission level are used to offer a novel strategy. Intelligent charging algorithms would be implemented by charging stations at the primary level to regulate individual EV charging according to factors such as battery state of charge, time of use rates, etc. This aids in load distribution. Distribution system operators would interact with charging stations at the secondary level to regulate aggregate charging demands according to distribution grid circumstances. By doing this, electricity quality is preserved. fully. To maintain transmission stability during peak EV charging times, distribution operators would receive limits from transmission system operators at the tertiary level. The goal of the hierarchical control technique is to prevent adverse grid effects while enabling the coordinated integration of large-scale EVs into Libya's power system. This strategy requires a suitable communication infrastructure to be put into practice.

References

[1] Nassar Y, Aissa K, Alsadi S. Air Pollution Sources in Libya. Research & Reviews: Journal of Ecology and Environmental Sciences, vol.6, no.1, 2018, 63-79. http://www.rroij.com/open-access/air-pollution-sources-in-libya.php?aid=86543.

[2] Yasser F. Nassar, Mohammad J. Abdunnabi, Mohamed N. Sbeta, Ahmad A. Hafez, Khaled A. Amer, Abdulaziz Y. Ahmed, Basim Belgasim, Dynamic analysis and sizing optimization of a pumped hydroelectric storage-integrated hybrid PV/Wind system: A case study, Energy Conversion and Management. Vol.229, 2021. https://doi.org/10.1016/j.enconman.2020.113744.

[3] Y. Nassar, H. El-Khozondar, W. El-Osta, S. Mohammed, M. Elnaggar, M. Khaleel, A. Ahmed, A. Alsharif, Carbon footprint and energy life cycle assessment of wind energy industry in Libya, Energy conversion and management, vol.300, 2024, 117846, https://doi.org/ 10.1016/j.enconman.2023.117846.

[4] Yasser F. Nassar, Hala J. El-khozondar, Abdussalam A. Ahmed, Abdulgader Alsharif, Mohamed M. Khaleel, Rifa J. El-Khozondar, A new design for a built-in hybrid energy system, parabolic dish solar concentrator and bioenergy (PDSC/BG): A case study – Libya, Journal of Cleaner Production, vol.441, 2024, 140944, https://doi.org/10.1016/j.jclepro.2024.140944.

[5] M. Khaleel, Z. Yusupov, M. Guneser, Y. Nassar, H. El-Khozondar, A. Ahmed, A. Alsharif. Towards Hydrogen Sector Investments for Achieving Sustainable Electricity Generation. Solar Energy and Sustainable Development Journal, vol.13, no.1, 2024, 71–96.

[6] Y. Nassar, H. El-Khozondar, A. Ahmed, I. Imbayah, A. Alsharif, M. Khaleel, Assessing the Viability of Solar and Wind Energy Technologies in Semi-Arid and Arid Regions: A Case Study of Libya's Climatic Conditions, Applied Solar Energy, vol. 60, no.1, 149-170, 2024.

[7] Y. F. Nassar, S.Y. Alsadi, G. M. Miskeen, H. J. El-Khozondar, N. M. Abuhamoud. Atlas of PV Solar Systems Across Libyan Territory. 2022 International Conference on Engineering & MIS (ICEMIS), Istanbul, Turkey, 04-06 July 2022. doi.org/10.1109/ICEMIS56295.2022.9914355.

[8] H. Awad, Y. Nassar, R. Elzer, I. Mangir, H. El-Khozondar, M. Khaleel, A. Ahmed, A. Alsharef, M. Salem, A. Hafez, Energy, economic and environmental feasibility of energy recovery from wastewater treatment plants in mountainous areas: a case study of Gharyan city –Libya, Acta Innovations, vol.50, no.4, 2023, 46-56. https://doi.org/10.32933/ActaInnovations.50.5.

[9] A. Alsharif, A. Ahmed, M. Khaleel, Y. Nassar, M. Sharif, H. El-Khozondar, Power Management and Sizing Optimization for Isolated Systems Considering Solar, Battery, and Diesel Generator based on Cost and Reliability under Murzuq and Sabha Cities Weather. International conference on research of mechanical design automation and materials, 28th -29th Sep 2023, bhopal, Madhya Pradesh, India.

[10] I. Imbayah, A. Ahmed, A. Alsharif, M. Khaleel, A. Alarga, “A Review of the Possibility Integrating the Solar System into the Libyan Railway Transportation”. African Journal of Advanced Pure and Applied Sciences (AJAPAS), Volume 2, Issue 2, April-June 2023, Page No: 1-10.

[11] A. O. M. Maka and J. M. Alabid, “Solar energy technology and its roles in sustainable development,” Clean Energy, vol. 6, no. 3, pp. 476–483, Jun. 2022, doi: 10.1093/ce/zkac023.

[12] K. S. Sambaiah, “A Study on Challenges in Adoption of Electric Vehicle and Vehicle-to-Grid Technologies in India,” Turkish J. Electr. Power Energy Syst., vol. 2, no. 2, pp. 197–218, 2022, doi: 10.5152/tepes.2022.22023.

[13] N. Shaukat et al., “A survey on electric vehicle transportation within a smart grid system,” Renew. Sustain. Energy Rev., vol. 81, no. May 2017, pp. 1329–1349, Jan. 2018, doi: 10.1016/j.rser.2017.05.092.

[14] M. A. Hannan, M. M. Hoque, A. Hussain, Y. Yusof, and P. J. Ker, “State-of-the-Art and Energy Management System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues and Recommendations,” IEEE Access, vol. 6, pp. 19362–19378, Mar. 2018, doi: 10.1109/ACCESS.2018.2817655.

[15] A. W. Thompson and Y. Perez, “Vehicle-to-Everything (V2X) energy services, value streams, and regulatory policy implications,” Energy Policy, vol. 137, no. December 2019, p. 111136, Feb. 2020, doi: 10.1016/j.enpol.2019.111136.

[16] A. Alsharif, A. A. Ahmed, M. M. Khaleel, A. S. Daw Alarga, O. S. M. Jomah, and I. Imbayah, “Comprehensive State-of-the-Art of Vehicle-To-Grid Technology,” in Proceeding - 2023 IEEE 3rd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering, MI-STA 2023, IEEE, May 2023, pp. 530–534. doi: 10.1109/MI-STA57575.2023.10169116.

[17] M. Khan et al., “Integration of Large-Scale Electric Vehicles into Utility Grid: An Efficient Approach for Impact Analysis and Power Quality Assessment,” Sustainability, vol. 13, no. 19, p. 10943, Oct. 2021, doi: 10.3390/su131910943.

[18] A. Demirci, S. M. Tercan, U. Cali, and I. Nakir, “A Comprehensive Data Analysis of Electric Vehicle User Behaviors Toward Unlocking Vehicle-to-Grid Potential,” IEEE Access, vol. 11, pp. 9149–9165, 2023, doi: 10.1109/ACCESS.2023.3240102.

[19] M. Almaktar, A. M. Elbreki, and M. Shaaban, “Revitalizing operational reliability of the electrical energy system in Libya: Feasibility analysis of solar generation in local communities,” J. Clean. Prod., vol. 279, p. 123647, 2021, doi: 10.1016/j.jclepro.2020.123647.

[20] Z. A. Arfeen et al., “Energy storage usages: Engineering reactions, economic-technological values for electric vehicles-A technological outlook,” Int. Trans. Electr. Energy Syst., no. March, p. e12422, Apr. 2020, doi: 10.1002/2050-7038.12422.

[21] M. S. Mastoi et al., “An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends,” Energy Reports, vol. 8, pp. 11504–11529, Nov. 2022, doi: 10.1016/j.egyr.2022.09.011.

[22] S. Huang, W. Liu, J. Zhang, C. Liu, H. Sun, and Q. Liao, “Vehicle-to-grid workplace discharging economics as a function of driving distance and type of electric vehicle,” Sustain. Energy, Grids Networks, vol. 31, p. 100779, Sep. 2022, doi: 10.1016/j.segan.2022.100779.

[23] F. Zhang, X. Hu, R. Langari, and D. Cao, “Energy management strategies of connected HEVs and PHEVs: Recent progress and outlook,” Prog. Energy Combust. Sci., vol. 73, pp. 235–256, Jul. 2019, doi: 10.1016/j.pecs.2019.04.002.

[24] M. Nour, J. P. Chaves-Ávila, G. Magdy, and Á. Sánchez-Miralles, “Review of Positive and Negative Impacts of Electric Vehicles Charging on Electric Power Systems,” Energies, vol. 13, no. 18, p. 4675, Sep. 2020, doi 10.3390/en13184675.

[25] M. Nour, J. P. Chaves-Ávila, G. Magdy, and Á. Sánchez-Miralles, “Review of Positive and Negative Impacts of Electric Vehicles Charging on Electric Power Systems,” Energies, vol. 13, no. 18, p. 4675, Sep. 2020, doi 10.3390/en13184675.

[26] S. Islam, A. Iqbal, M. Marzband, I. Khan, and A. M. A. B. Al-Wahedi, “State-of-the-art vehicle-to-everything mode of operation of electric vehicles and its future perspectives,” Renew. Sustain. Energy Rev., vol. 166, no. March, p. 112574, 2022, doi: 10.1016/j.rser.2022.112574.

[27] A. Alsharif, C. W. Tan, R. Ayop, K. Y. Lau, and A. M. D. Dobi, “A rule-based power management strategy for Vehicle-to-Grid system using antlion sizing optimization,” J. Energy Storage, vol. 41, no. April, p. 102913, 2021, doi: 10.1016/j.est.2021.102913.

[28] J. H. Angelim and C. de M. Affonso, “Probabilistic Impact Assessment of Electric Vehicles Charging on Low Voltage Distribution Systems,” in 2019 IEEE PES Innovative Smart Grid Technologies Conference - Latin America (ISGT Latin America), IEEE, Sep. 2019, pp. 1–6. doi: 10.1109/ISGT-LA.2019.8895494.

[29] K. Mahmud, G. E. Town, S. Morsalin, and M. J. Hossain, “Integration of electric vehicles and management in the internet of energy,” Renew. Sustain. Energy Rev., vol. 82, no. October 2016, pp. 4179–4203, 2018, doi: 10.1016/j.rser.2017.11.004.

[30] M. Bilal, I. Alsaidan, M. Alaraj, F. M. Almasoudi, and M. Rizwan, “Techno-Economic and Environmental Analysis of Grid-Connected Electric Vehicle Charging Station Using AI-Based Algorithm,” Mathematics, vol. 10, no. 6, p. 924, Mar. 2022, doi: 10.3390/math10060924.

[31] M. Liu, P. K. Phanivong, Y. Shi, and D. S. Callaway, “Decentralized Charging Control of Electric Vehicles in Residential Distribution Networks,” IEEE Trans. Control Syst. Technol., vol. 27, no. 1, pp. 266–281, Jan. 2019, doi: 10.1109/TCST.2017.2771307.

[32] M. Abid, M. Tabaa, A. Chakir, and H. Hachimi, “Routing and charging of electric vehicles: Literature review,” Energy Reports, vol. 8, no. May, pp. 556–578, 2022, doi: 10.1016/j.egyr.2022.07.089.

[33] F. Ahmad, A. Iqbal, I. Ashraf, M. Marzband, and I. Khan, “Optimal location of electric vehicle charging station and its impact on distribution network: A review,” Energy Reports, vol. 8, no. February, pp. 2314–2333, 2022, doi 10.1016/j.egyr.2022.01.180.

[34] P. Bastida-Molina, E. Hurtado-Pérez, Á. Pérez-Navarro, and D. Alfonso-Solar, “Light electric vehicle charging strategy for low impact on the grid,” Environ. Sci. Pollut. Res., Apr. 2020, doi: 10.1007/s11356-020-08901-2.

[35] E. Ancillotti, R. Bruno, and M. Conti, “The role of communication systems in smart grids: Architectures, technical solutions, and research challenges,” Comput. Commun., vol. 36, no. 17–18, pp. 1665–1697, 2013, doi: 10.1016/j.comcom.2013.09.004.

[36] E. M. Szumska, “Electric Vehicle Charging Infrastructure along Highways in the EU,” Energies, vol. 16, no. 2, p. 895, Jan. 2023, doi: 10.3390/en16020895.

[37] M. İnci, M. M. Savrun, and Ö. Çelik, “Integrating electric vehicles as virtual power plants: A comprehensive review on vehicle-to-grid (V2G) concepts, interface topologies, marketing, and prospects,” J. Energy Storage, vol. 55, no. March, p. 105579, Nov. 2022, doi 10.1016/j.est.2022.105579.

[38] D. L. Greene, E. Kontou, B. Borlaug, A. Brooker, and M. Muratori, “Public charging infrastructure for plug-in electric vehicles: What is it worth?,” Transp. Res. Part D Transp. Environ., vol. 78, no. October 2019, p. 102182, 2020.

[39] Martyushev, N. V., Boris V. Malozyomov, Svetlana N. Sorokova, Egor A. Efremenkov, and Mengxu Qi. 2023. "Mathematical Modeling the Performance of an Electric Vehicle Considering Various Driving Cycles" Mathematics 11, no. 11: 2586. https://doi.org/10.3390/math11112586.