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# TECHNICAL CHALLENGES, IMPACTS AND PERSPECTIVES FOR ELECTRIC VEHICLES (EVS)

# DESAFIOS TÉCNICOS, IMPACTOS E PERSPECTIVAS PARA VEÍCULOS ELÉTRICOS (EVS)

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**Abstract:** Imminent environmental issues and growing concerns about global energy crises are driving the need for new opportunities and technologies that can meet the significantly increased demand for cleaner generation and products, zero-carbon, and sustainable energy systems. This requires the development of more efficient transport and energy generation. Shifting from the transport model to electric is a promising approach for ecological systems and for reducing climate change issues. This article reviews the current status, latest deployment, and challenging issues in installing an infrastructure and charging system for electric vehicles (EVs) in conjunction with various international standards and charge codes. The article further analyzes the impacts of (Evs) and

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perspectives on society. A complete review of charging systems for (Evs) with battery charging techniques. In addition, the beneficial and harmful impacts of (Evs) are categorized and carefully reviewed. Corrective measures for harmful impacts are presented and the benefits obtained from them are highlighted. Bidirectional charging provides the vehicle's fundamental characteristic for smart grid technology. In this article, current challenging issues due to the massive deployment of (Evs) and future research trends are also presented. Corrective measures for harmful impacts are presented and the benefits obtained from them are highlighted. Bidirectional charging provides the vehicle's fundamental characteristic for smart grid technology. In this article, current challenging issues due to the massive deployment of (Evs) and future research trends are also presented. Corrective measures for harmful impacts are presented and the benefits obtained from them are highlighted. Bidirectional charging provides the vehicle's fundamental characteristic for smart grid technology. In this article, current challenging issues due to the massive deployment of (Evs) and future research trends are also presented.
**Key words:** Electric Mobility, Electric Vehicles (EVs), Electric Charging.

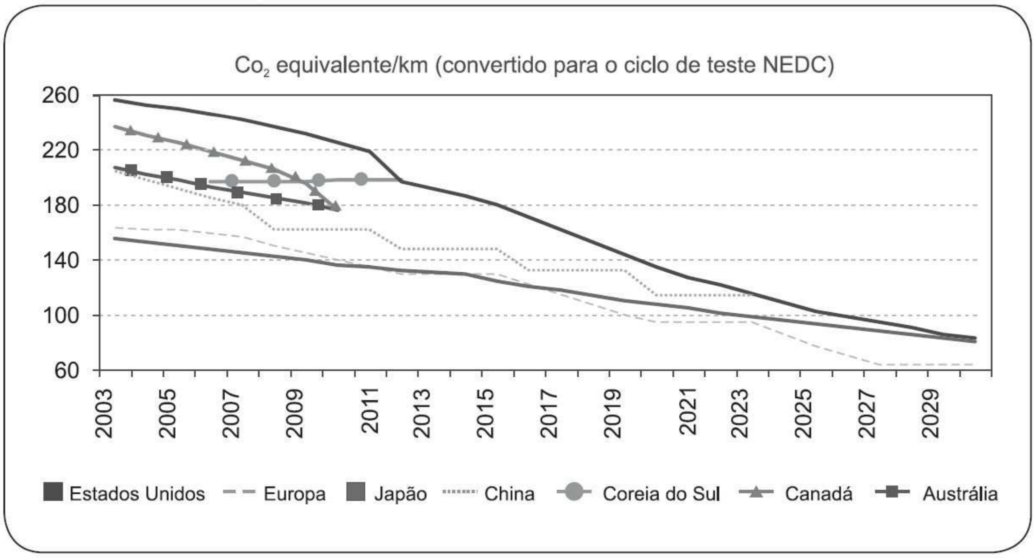
**Resumo:** As iminentes questões ambientais e as crescentes preocupações com as crises globais de energia estão levando a necessidade de novas oportunidades e tecnologias que possam atender à demanda significativamente maior por geração e produtos mais limpos, zero carbono e sistemas de energia sustentável. Isso requer o desenvolvimento de transporte e geração de energia mais eficiente. A mudança do modelo de transporte para elétrico é uma abordagem promissora para os sistemas ecológicos e para reduzir os problemas de mudança climática. Este artigo inspeciona o status atual, implantação mais recente e questões desafiadoras na instalação de um sistema de infraestrutura e carregamento de veículos elétricos (EVs) em conjunto com vários padrões internacionais e códigos de cobrança. O artigo analisa ainda mais os impactos de (Evs) e perspectivas na sociedade. Uma avaliação completa dos sistemas de carregamento para (Evs) com técnicas de carregamento de bateria. Além disso, os impactos benéficos e prejudiciais dos (Evs) são categorizados e cuidadosamente revisados. Medidas corretivas para impactos prejudiciais são apresentadas e os benefícios obtidos a partir delas são destacados. O carregamento bidirecional oferece a característica fundamental do veículo para a tecnologia de smart grid. Neste artigo, as atuais questões desafiadoras devido à implantação massiva de (Evs) e tendências de pesquisa futuras também são apresentadas.
**Palavras Chave:** Mobilidade Elétrica, Veículos Elétricos (EVs), Carregamento Elétrico.

## INTRODUCTION

In recent years, air pollution caused by the burning of fossil fuels in the transport, industrial, and energy sectors is becoming a challenge for the environment. Climate change and the rising cost of energy and fossil fuels are considerable issues in the world today (Mohammad, 2020). All of these challenging concerns are directly related to the three and main sectors mentioned above, which make heavy use of fossil fuels. And all researchers and governments are investing time and money to reduce dependence on fossil fuels and replace them with clean solutions.

Growing concerns about the environment and the need for clean energy have contributed to the demand for electric vehicles (EVs) as a means of transport. Today, many countries around the world are contributing to achieving certain environmental clean energy goals. To reduce the impact of higher fuel prices and to create environmental policies with higher standards, the electric vehicle is an alternative to meet the desire for a green source of transport with fewer emissions and better fuel economy. The development and deployment of electric vehicle technology is an emerging solution to the problems mentioned above with its attractive approach to having more mileage with reduced emissions (C. Kong et al., 2018).

Graph 01 - Environmental legislation of countries




Source: CMS

The contribution of the global transport sector is also increasing the popularity of day-to-day (EVs) with the ultimate goal of eliminating $CO^2$ emissions. Replacing internal combustion engines with (EVs) is an improved cost-effective approach because the electrification of key parts in the energy and transportation sectors (EVs) can be broadly classified into hybrid EVs (HEVs) and plug-in (EVs) (PEVs). PEVs are further subcategorized into plug-in hybrid EVs (PHEVs) and battery (EVs). In (HEVs), the battery cannot be recharged from an external power source as opposed to (PEVs). In the context of this article, the plug-in (EVs) will be incorporated into EVs (Mohammad, 2020).

Recently, many research studies have shown that because the green environment and energy-saving feature becomes the easiest way of implementation, EV technology brings additional benefits over conventional energy technologies. In urban areas of the world, EVs are projected to increase substantially and will have greater acceptance in the transportation market due to their greater efficiency. Many impressive features can be achieved by connecting the (EVs) to an electrical grid such as load balancing, reactive power support, active power regulation, and support for renewable energy resources.

In this sense, different public policies have been implemented to support electrification in the transport sector in the USA, UK, and even Brazil. There are many large organizations including IEEE, SAE (Society of Automotive Engineers), and IWC (Infrastructure Working Council), that are working to prepare different standards and codes relating to the utility interface. To achieve widespread acceptance, EVs still face some significant barriers, such as incremental costs, battery life cycle, deficiency in EV charging infrastructure, and battery charger issues (Abdullah et al., 2020). Another big problem is the production of harmful harmonics by electrical chargers (EVs) that have serious impacts on the parameters of the distribution system.

Figure 1 - Electric station


Source: Author

The charging behavior of (EVs) in domestic areas takes place at night in the owner's garage, where electric vehicles are plugged into an outlet suitable for slow charging, ie level

1 charging. A higher-level charging (Level 2) requires a 220-240V outlet and is designated as the basic billing method in public and private facilities. Currently, most research addresses the Tier 2 charging mode as it can be employed in most environments and provides more than enough power. Charging levels 1 and 2 are generally used for single-phase solutions. Commercial applications and public domains preferentially use higher charge Level 3 and DC fast loading (Z. Darabi et al., 2011). Areas near hotels, stores, malls, and parking lots have chargers for energy levels 2 and 3 in Cascavel-PR. There are type 2 gas stations in gas stations in front of the city hall and on the main avenue of the city. A brief comparison of different power level charges as described by various international standards is summarized in Table 1.

The charging system with unidirectional power flow capability has benefits such as minimal hardware, fewer interconnect complications, and less battery degradation. The other bidirectional energy flow charging system has several features, including energy stabilization, smart grid technology, and controlled power conversion (Abdullah et al., 2020).

A direct connection will be used between the charging input and the connector in the case of coupled charging systems. For inductive charging systems, energy can be transferred wirelessly. In research studies, the authors discussed inductive charging systems for two basic charging levels (1 and 2). Inductive charging systems can be mobile or fixed.

Technical studies are being carried out to assess the impacts of (EVs) with special emphasis on economic, environmental, and power grid impact assessments. The economic impacts of (EVs) can be examined from a dual perspective including the power grid and EV owners. The paper on the various types of generation with photovoltaic systems, Biodigesters, and wind electricity systems is considerable for examining the general economic and environmental analysis of electric vehicles (C. Kong et al., 2018). Negative environmental impacts (EVs) will be observed when charging is dependent on fossil fuel power units such as the use of a diesel generator to power an electro-station. Based on comprehensive research from various technical studies, the considerable issues associated with the integration of (EVs) for power networks are: increase in load during peak hours, overload of the power system and its components, transmission losses, power deviations. voltage, phase imbalance problems.

## MATERIAL AND METHODS

INFRASTRUCTURE AND LOADING POWER SYSTEM LEVELS FOR EVs

Substantial and different parameters including impacts on the electrical grid, cost, equipment, location, total charging time, and the amount of power can be understood with the help of charging infrastructure and various charging power levels. Many considerable issues need to be discussed concerning the implementation and development of charging station infrastructure such as (1) Standardization of charging stations, (2) Time and extent of charging, (3) Demand and distribution policies, (4) Regulatory procedures (Z. Darabi et al., 2011). Cost and requirements for onboard energy storage systems can be reduced with the availability of charging infrastructure. The main components of the Electric Stations are:

- Vehicle charging codes and connectors.
- Billing is in public or residential places.
- multiple plugs needed for attachment.
- Power outlets and protective equipment.

Two sets of configurations are primarily used to have all of the aforementioned equipment: a specific cable set and a pedestal-mounted box set. Basic configurations differ from country to country and sometimes the location can also affect the design based on various parameters to be considered, such as electrical connections, grid, voltage, frequency, and standards relating to transmission systems. Generally, the expected charging time (EVs) is a nighttime duration at home by (EVs) different owners as described by the Electric Power Research Institute (EPRI). For this reason, the main options should use power level 1 and 2 charging equipment (C. Kong et al., 2018).

Figure 2 - Connector Type01

Source: Author

The main and basic method that can provide services in public and private places is Electric Posts Level 2. To have lesser electronic power, onboard installation is provided at this level of charging power. In-home and public places, the charging level requires an Electric Station with a connection installation. As most homes have 220Vac - 240Vac Two-Phase service availability, appliances associated with this power level can charge the vehicle battery overnight (C. Kong et al., 2018). The Tier 2 charging method is preferred due to its fast-charging time and standardization of vehicle-to-charger connection. According to the technical study. SAE's J1772 has a combo connector providing a connection for AC on the top side and the bottom side has a two-pin DC connector.

Figure 3 - Type02 Connector

Source: Author

The Power Level 3 Electric Station charging process is used commercially and provides the fastest charging time in less than an hour. It is comparable to gas stations and can be installed at rest points on highways and urban filling stations. Supply regulated AC-DC conversion, an off-board charger is required. Charging power level 3 is not suitable for use in homes.

Figure 4 - Connector Type02 and 03

Source: Author

For DC plugs and hardware, different standards are in stages of improvement. A new standard corresponding to DC fast charging called “CHADeMO" from Japanese national protocol is gaining recognition very quickly all over the world. This pattern is designed to increase the deployment of (EVs) and to address issues about optimal mileage among (EV) users. This standard can recharge the (EV) within 30 min up to 80% of charge state via optimal DC charging power.

However, the main concerns are the cost of execution, which is higher than other electrical stations. The SAE standard suggested that the Electric Station of the first two energy load levels (Level 1 and 2) should be accommodated in the vehicle; however, the power station at level 3 must be outside the vehicle (Jing W et al., 2018). To carry out fast charging at commercial points, charging power levels 2 and 3 must be employed at public stations. Lower charge levels (1 and 2) have less impact on peak demand on the electrical grid compared to higher fast charging which can quickly overwhelm all distribution equipment. Levels 2 and 3 of load power have considerable impacts on distribution systems:

Table 1 - Types of levels for charging of Electric Stations

| Loading Level Type | Loader | Typical Use | Power Interface | Power in kW |
|---|---|---|---|---|
| **SAE Standards: AC and DC Charging** | | | | |
| Level 1 load - slow 230VAC (Europe) 120VAC (USA) | Single-phase on-board | commercial or at home | Any point of convenience | P: 1.4 (12A) P: 1.9 (20A) |
| Level 2 Semi - fast 400VAC (Europe) 220VAC – 240VAC (USA) | Single-phase / Three-phase on-board | Commercial or home use | EV electric station | P: 4 (17A) P: 8 (32A) P: 19.2 (80A) |
| Level 3 Fast 208-600 VAC | Off-board three-phase | shopping centers, shopping mall parking, commercial | EV electric station | P: 50 P: 100 |
| Level 1 Power DC 200-450 VDC | Offboard | Dedicated electric station | EV electric station | P: 40 (80A) |
| Level 2 Power DC 200-450 VDC | Offboard | Dedicated electric station | EV electric station | P: 90 (200A) |
| Level 3 Power DC 200-600 VDC | Offboard | Dedicated electric station | EV electric station | P: 240 (400A) |
| **IEC Standards: AC and DC Charging** | | | | |
| Level 1 Power AC | Single-phase on-board | commercial or at home | Any point of convenience | P: 4-7.5 (16A) |
| Level 2 Power AC | Single-phase / Three-phase on-board | Commercial or home use | EV electric station | P: 8-15 (32A) |
| Level 3 Power AC | Off-board three-phase | shopping centers, shopping mall parking, commercial | EV electric station | P: 60-120 (250A) |
| FAST DC Power | Offboard | Dedicated electric station | EV electric station | P: 1000-2000 (400A) |
| **CHAdeMO standards Japanese standard loading** | | | | |
| FAST DC Power | Offboard | Dedicated electric station | EV electric station | 62.5 (125A) |

Source: EV recharge patterns that are available in the market today.

In Brazil, there are still no regulations for charging EVs (EVs) on federal roads and in the cities mentioned in this article, what exists are rates of unit owners who already provide these services to their unit owners as one more service (ABVE, 2020).

In Brazil, the most sold electric vehicles use the plug patterns below figure-05 and figure-06.

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Figure 5 - Type-01 socket for AC charging – Slow charging.


| Pin Nº | Função / Atribuição |
|---|---|
| 1 | Alimentação fase 1 |
| 2 | Alimentação fase 2 |
| 3 | Controle Piloto |
| 4 | Detecção de Proximidade |
| 5 | Terra |

Source: author

Figure 6 - Type-02 socket for AC/DC charging – Semi-Rapid charging.


| Pin Nº | Função / Atribuição |
|---|---|
| 1 | Detecção de Proximidade |
| 2 | Controle Piloto |
| 3 | Terra |
| 4 | Alimentação fase 1 |
| 5 | Alimentação fase 2 |
| 6 | Alimentação fase 3 |
| 7 | Neutro |

Source: author

**Benefits and Impacts of a V2G Vehicle**

Electric Vehicles with two-way chargers provide a distinct benefit as a means of a technology recognized as Vehicle to Network (V2G) technology. When batteries (EVs) are not in use but still connected to a grid, they can supply power to an electrical grid at its greatest load demand and therefore increase grid efficiency, this refers to a V2G technology (Lee et al., 2018). The expected increase in penetrations (EVs) makes it possible to implement V2G technology. Bidirectional charging leads to the possibility of energy flow in both directions between the power grid and (EVs). The (EVs) are capable of serving as a load as well as a power supplier to the grid. Concerning public services, the (EVs) can be seen as a load and a source of generation, acting as backup generators at the distribution level. EVs can offer energy storage services to utility networks. To charge the battery of an Electric Vehicle and to support the energy network, bidirectional energy flow employs the concept of energy exchange between the energy networks and the batteries of Electric vehicles (Zhang, 2020).

Bi-directional power flow with the help of V2G technology increases power grid flexibility to control the mechanism of energy stored in batteries (EVs) and to maintain the sustainability, reliability, and efficiency of a power grid. The substantial benefits provided by the bidirectional V2G technology are support for active power and reactive power, support for power factor regulation, and help to improve the integration of variable renewable energy resources. Load balancing by valley filling and peak load reduction is one of the main features that can be achieved by bidirectional V2G. The wind and solar photovoltaic systems are such renewable energy resources that the energy generated from them is of an unpredictable and inconsistent nature.

This is a kind of disadvantage of a non-stable network in a generation, as weather conditions have a major impact on them. Interaction of EVs with renewable energy is an emerging solution to resolve the intermittent nature of generation swings, using EVs as an energy storage point (DT Hoang et al., 2018). Load balancing by valley filling and peak load reduction is one of the main features that can be achieved by bidirectional V2G. The wind and solar photovoltaic systems are such renewable energy resources that the energy generated from them is of an unpredictable and inconsistent nature. This is a kind of disadvantage of a non-stable network in a generation, as weather conditions have a major impact on them. Interaction of EVs with renewable energy is an emerging solution to resolve the intermittent nature of generation swings, using EVs as an energy storage point (DT Hoang et al., 2018). The wind and solar photovoltaic systems are such renewable energy resources that the energy generated from them is of an unpredictable and inconsistent nature. This is a kind of disadvantage of a non-stable network in a generation, as weather conditions have a major impact on them.

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## FINAL CONSIDERATIONS

This document reviews the current status and latest deployment and challenging issues in infrastructure (EVs) and billing systems implementations in conjunction with various standards and billing codes. It further analyzes the impacts and perspectives of (EVs) on society. The paper highlights international standards relating to billing methods, network integration, power quality issues, security limitations, communication networks, and equipment maintenance that are required for large-scale deployment of (EVs). In addition, a complete review of charging systems including inductive charging, conductive charging networks, and battery switching for (EVs) with various types of fast and slow battery charging techniques are explained. Furthermore, the beneficial and harmful impacts of (EVs) are categorized and thoroughly reviewed with corrective measures for both harmful impacts and beneficial impacts. Bidirectional charging offers the fundamental feature of vehicle technology for Smart Grid and V2G. Optimal charging methodologies should be adopted to circumvent issues of impacts from (EVs).

The effective realization of V2G technology and electrification of the transport sector are unquestionably continuing motivations. However, V2G technology is a captivating research perspective, which can bring many potential economic, environmental benefits and must provide various services to power the grid. Numerous benefits gained from EVs will undoubtedly gain considerable attention from utility operators and EV owners soon.

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## REFERENCES

Abdullah, HM; Kamel, RM; Tahir, A.; Sleit, A.; Gastli, A. The Simultaneous Impact of EV Charging and PV Inverting Reactive Power on the Hosting Distribution System's Performance: A Case Study in Kuwait. Energies 2020, 13, 4409.

ABVE – BRAZILIAN ASSOCIATION OF ELECTRIC VEHICLE. What is regenerative braking? Available at: <http://www.abve.org.br/PF/ExibePF. asp?code=0009>. Accessed on: 26.22.2020.

Z. Darabi and M. Ferdowsi, "Aggregated impact of plug-in hybrid electric vehicles on electricity demand profile," IEEE Trans. Sustain. Energy, vol. 2, no. 4, pp. 501–508, Oct. 2011.

K. Throngnumchai, T. Kai, and Y. Minagawa, "A study on receiver circuit topology of a cordless battery charger for electric vehicles," in Proc. IEEE Energy Conversion Congregation Expo., Sep. 2011, pp. 843–850.

Jing W, Yan Y, Kim I, Sarvi M. Electric vehicles: A review of network modeling and future research needs. Advances in Mechanical Engineering. January 2016. doi:10.1177/1687814015627981

Ye K, Li P. A new adaptive PSO-PID control strategy of hybrid energy storage system for electric vehicles. Advances in Mechanical Engineering. September 2020. doi:10.1177/1687814020958574

C. Kong, R. Jovanovic, IS Bayram, and M. Devetsikiotis, "A hierarchical optimization model for a network of electric vehicle charging stations," Energies, vol. 10, no. 5, p. 675, 2017.

J. Kiviluoma and P. Meibom, "Methodology for modeling plug-in electric vehicles in the power system and cost estimates for a system with either smart or dumb electric vehicles," Energy, vol. 36, no. 3, pp. 1758–1767, 2011.

DT Hoang, P. Wang, D. Niyato, and E. Hossain, "Charging and discharging of plug-in electric vehicles (PEVs) in vehicle-to-grid (V2G) systems: A cyber insurance-based model," IEEE Access, vol. 5, pp. 732-754, 2017, doi: 10.1109/ACCESS.2017.2649042.

Muhammad, A.; Zamora, R.; Lie, TT Integration of Electric Vehicles in the Distribution Network: A Review of PV Based Electric Vehicle Modeling. Energies 2020, 13, 4541

NML Tan, T. Abe, and H. Akagi, "Design and performance of a bidirectional isolated DC–DC converter for a battery energy storage system," IEEE Trans. Power Electron., vol. 27, no. 3, pp. 1237–1248, Mar. 2012.

F. Un-Noor, S. Padmanaban, L. Mihet-Popa, MN Mollah, and E. Hossain, "A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development, " Energies, vol. 10, no. 8, p. 1217, 2017.

P. Braun. (Apr. 2015). Don't Look so Smug: Your Tesla Might be Worse for the Environment Than a Gas Car. Digital Trends. Accessed: Jan. 9, 2018. [Online]. Available: https://www.digitaltrends.com/cars/hold-smugness-tesla-might-just-worse-environment-know/

R. Liu, L. Dow, and E. Liu, ''A survey of PEV impacts on electric utilities,'' in Proc. IEEE PES Innov. Smart Grid Technol. (ISGT), Jan. 2011, pp. 1–8.

Zhang, J.; Che, L.; Wang, L.; K. Madawala, U. Game-Theory Based V2G Coordination Strategy for Providing Ramping Flexibility in Power Systems. Energies 2020, 13, 5008.

Lee, H.-J.; Oh, B.-C.; Kim, S.-W.; Kim, S.-Y. V2G Strategy for Improvement of Distribution Network Reliability Considering Time Space Network of EVs. Energies 2020, 13, 4415