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A Comprehensive Technique for Reducing Power Loss in Distribution Networks Utilizing Gridable Electric Vehicles and Distributed Generators using Meta Heuristic Techniques

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Abstract:- The increase in the quantity of Electric Vehicles (EVs) over the distribution network emphasizes an additional demand on the system while it is being charged. But if the EVs are employed to support the utility depending on the need, the same turns out to be favorable. The proposed research is to identify the ways to cut down on power losses in the distribution system. with the presence of distributed generators (DG's) by optimally scheduling both the grid-to-vehicle (G2V) and vehicle-to-grid (V2G) operating modes of EVs using Grasshopper optimization and improving the voltage profile. The analysis is carried for multiple cases of DGs, EVs acting as load and source based on the demand response in the distribution system. An evaluation of the performance is carried out by considering IEEE 69 bus system, and comparing with the optimization algorithms to determine its efficacy.

***Keywords**: Grid to Vehicle, Vehicle to Grid, Power loss, Voltage Profile.*

1. Introduction

The thought-provoking in the environmental and economic benefits of EVs have made them a potentially viable alternative to conventional automobiles that are powered by fossil fuels. It is believed that, in the future of transportation, EVs will play a crucial part in altering the landscape. In the future years, it is predicted that there will be a substantial rise in the number of people who purchase EVs, as stated in the national electric mobility mission plan that has been adopted by the Government of India. This initiative aims to facilitate the widespread usage of EVs throughout the country. Incorporating a fleet of electric vehicles into the power system network brings a number of benefits as well as significant problems. The high adoption rate of electric vehicles has been a significant factor in this process. The growing number of EVs has raised concerns about the potential strain, it may put on the expansion of power distribution systems. EV load integration and mobile grid connectivity in the modern world has significantly impacted features of the electricity grid's energy consumption. This integration has led to an increase in energy demand, reaching beyond the maximum amount of peak demand. Consequently, there is a need for a modern self-attention grid to effectively manage and address these evolving energy demands [1]. Moreover, it is important to consider the potential occurrence of an extreme case, wherein a significant portion of the EV market return to their residences and simultaneously link their EVs to the power grid for charging during times of high demand, alongside the conventional load. The uncoordinated integration of EVs into distribution system networks has been identified as a factor that imposes an additional burden on these networks [2].

The observed outcome is anticipated to lead to an escalation in peak load demand, potentially resulting in congestion within the distribution system. The utilization of renewable energy sources (RES) is experiencing a significant growth in order to address the growing global electricity consumption. The incorporation of RESs into electrical grids is a critical step towards achieving sustainability in the global energy landscape. As a result of the persistent increase in the demand for energy and concerns about environmental degradation escalate, the importance of transitioning to renewable energy sources becomes increasingly evident. In order to secure a reliable and long- lasting power source for decades to come, this change is not an option but an absolute must. Another crucial aspect is the economic viability of renewable energy integration [3]. Advances in technology and economies of scale are making RES more competitive with traditional sources by drastically lowering their generating costs. Governments, businesses, and communities are recognizing monetary gains from renewable energy infrastructure investments, including increased employment opportunities, lower energy bills in the long run, and the development of a robust and sustainable green economy. A decentralization of power generation is possible via the use of distributed energy resources like small-scale wind turbines and solar panels installed on residential roofs. This not only enhances energy independence but also fosters a more resilient and adaptive energy infrastructure.

Numerous research studies have consistently demonstrated that a significant proportion of vehicles remain inactive for active transportation purposes, with estimates reaching as high as 95% of the total time [4]. The potential utilization of EV batteries for bidirectional electricity transfer between the vehicle and the electric distribution network has been a subject of interest in recent research. This concept involves leveraging the energy storage capacity of EV batteries to enable charging the vehicle's battery and sending it back to the power grid.

From a systems perspective, EVs can be considered as a kind of system for distributing energy storage. Utilizing V2G technology, EVs have the capacity to strengthen and prolong the life of electric power grids by offering peak power during periods of high demand [5]. This capability can contribute to load leveling and voltage stability. Also, during off-peak times, when renewable energy production is particularly high, EVs may be employed as storage devices to take in the extra power and inject it back into the grid [6]. EVs possess the capability to both charge and discharge power, enabling them to effectively manage the varying power outputs of RESs. Implementing effective charging and discharging techniques for EVs is crucial for ensuring the safe and economical functioning of distribution networks [7]. The utilization of the PEV in V2G mode and G2V mode in coordinated and well-scheduled operations has been found to be beneficial. In V2G mode, the PEV serves as an aiding source to support the grid system, while in G2V mode, it functions as a load in order to flatten the load curve [8]. The remaining part of the article follows as in the literature review is included in Section II, Section III follows with the problem’s formulation. Section IV deals with the Proposed Methodology, the results and discussion with the comparative research are provided in Section V. Finally, in Section VI, this work is concluded, which provides a suitable rationale for the results.

2. Literature Review

In a study conducted by Mohammad Saadatmandi et al., a charge management approach was developed with the aim of facilitating the incorporation of green power into the existing electrical infrastructure [9]. The research findings indicate that the program has been specifically developed to promote the utilization of RES among consumers, while simultaneously reducing reliance on conventional generators for power generation.

In their study, Rouyi Chen et al., addressed the issue of PHEV charging coordination crisis by formulating it as a two-stage constrained optimization problem. Their recommended method for optimum charge regulation was to effectively resolve this crisis in two stages. Firstly, it ensures all PHEVs with the most affordable overall charge cost [10]. Additionally, it effectively flattens the power demand curves for the grid. Moreover, this scheme is straightforward to implement in practical settings. In order to get an accurate evaluation of the efficiency of their plan, the researchers conducted numerical simulations.

Mostafa Rezaeimozafar et al., introduced a novel approach to assess the optimal positioning and extent of RES and EVCS. The research specifically focused on considering the transformative effects brought about by the widespread adoption of EVs [11]. In this study, a novel approach

Combining Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) is proposed to address a specific optimization problem. The performance of this approach is then compared to the widely used Differential Evolution (DE) method to assess its effectiveness.

Hadi et al., focuses on the modeling of vehicle charging demand, taking into account factors such as mileage and the time required for a full charge. The utilization of EV parking facilities has been explored as a means to not only provide charging infrastructure for EVs but also as a potential vehicle aggregator [12] . Additionally, the integration of renewable resources into the energy grid has been investigated, with a particular focus on their stochastic nature as generation resources.

In this study Quirós et al., have conducted an analysis on the effects, within the low voltage distribution network, the load of vehicles charging their batteries is placed on transformers and feeders. The investigation specifically focuses on various levels of vehicle penetration and the subsequent need for constructing new infrastructure [13]. This research study introduces a control method for vehicle charging that takes into consideration the thermal and voltage limitations of the network.

In this study, a novel bi-level method is introduced by Amini et al., for the allocation of parking lots for EVs. The proposed approach incorporates a probabilistic simulation of the behavior of EVs and takes into account of reliability constraints [14]. This paper also explores the utilization of the genetic algorithm as a means to address the objective problem at hand. The obtained results from the study demonstrate the effectiveness of EVs in enhancing the reliability of the system's operation. In a recent study, the Min et al., focus was on exploring various methods of recharging vehicles and analyzing their effects on reliability, economic factors, and environmental considerations. This research study does not take into account the EV usage as a function of its features and environmental variables [15].

From the above literature review, many studies focus on the optimal scheduling of G2V and V2G in distribution systems, but there's a research gap in addressing the specific challenges associated with the integration of RES. Investigating from the optimization of G2V and V2G to accommodate the intermittency and variability of RES, such as solar and wind, would be a valuable contribution. Existing research often assumes static conditions for scheduling G2V and V2G, overlooking the dynamic nature of distribution systems. A research gap exists in developing real-time optimization algorithms that can adapt to changing conditions, considering factors like varying energy demand, grid constraints, and the availability of EVs. While some studies focus on single-objective optimization, there is a need for research that explores the trade-offs between multiple objectives. Investigating the simultaneous optimization of economic benefits, grid reliability, and environmental impact could provide greater complexity in comprehending the optimum scheduling problem. Understanding the regulatory and policy framework surrounding G2V and V2G scheduling is essential. Research in this area can explore the barriers and facilitators posed by current regulations, as well as propose policy recommendations to incentivize optimal scheduling practices. This may include tariff structures, grid operator guidelines, and incentives for EV owners. With the increasing integration of smart grids and advanced communication technologies, there's a research gap in addressing potential cybersecurity threats to G2V and V2G systems. Investigating methods to secure the communication channels and data exchanges between EVs and the grid infrastructure is essential in order to ensure the dependability and integrity of the scheduling process.

This article has made the following contributions.

1. The optimization problem is addressed by employing a hybrid methodology to minimize power loss in a distribution system that incorporates DGs along with G2V and V2G.
2. The integration of the suggested intelligent EV charging method with the GOA is employed in this approach.
3. The comparison of the proposed algorithm results with the other metaheuristic algorithms.

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3. Problem formulation

$$P^{Loss}(K) = \sum_{k=1}^{24} I^2 R_k \quad (1)$$

Where

P^{Loss} is the Active Power Loss, I is the current, R is the Resistance, N is the bus number.

The equation for the power balance of the EV operating as a load is given by

$$\sum_{k=1}^{24} P_G(k) + \sum_{k=1}^{24} P_{DG}(k) = \sum_{k=1}^{24} P_D(k) + P^{Loss}(k) + P_{EV}(k) \quad (2)$$

The equation for the power balance of the EV acting as a DG

$$P_G + \sum_{i=1}^{N} P_{DG} + P_{EVDG} = P_D + P_L \quad (3)$$

Where P_G is the grid power ,P_{DG} is the DG power, P_D is the base load, P_{EVL} is the EV load,

P_{EVDG} is the EV being a source, PL is the active power loss. Electric vehicle charging and discharge constraints is given by

$$P_{ch,n,\Delta t} \leq Pmax_{ch,n} \quad (4)$$

$$P_{disch,n,\Delta t} \leq Pmax_{disch,n} \quad (5)$$

Where $P_{ch,n,\Delta t}$ is the power that electric vehicles may be charged at a particular moment. $P_{disch,n,\Delta t}$ the power that electric vehicles may be dis-charged at a particular moment. $Pmax_{ch,n}$ and $Pmax_{disch,n}$ the maximum power that electric vehicles may be charged and dis-charged at a particular moment.

The state of charge (SoC) of EV's battery must remain within this parameter.

$$SoC_{min} \leq SoC_n \leq SoC_{max} \quad (6)$$

The peak-to-average ratio (PAR) based on the level of demand for the system, the scheduling of events is determined. The fundamental objective of scheduling EVs is to minimize the PAR

$$PAR = \frac{P_{d,peak}}{P_{d,mean}} \quad (7)$$

The decision on either to charge or to drain the battery is made based on the size of the power ratio

$$PR = \frac{P_d(i)}{P_{d,mean}} \quad (8)$$

Ensure that the quantity of EVs granted in the subsequent step is greater than the number allocated in the initial step

$$\sum_{t=1}^{n} EV_{pit} \leq EVT$$

4. Results

An examination of the effects of EVs is provided in this section, on the distribution network by considering various operating conditions. In this study, a novel hybrid methodology is proposed to address the issue of power loss reduction in a DS that incorporates DGs and various clusters of EVs with various load conditions. The integration of the proposed EV charging method with the GOA is employed in this approach. The analysis is conducted on the IEEE 69-bus system, which serves as the standard benchmark for various power system studies and research.

The test system is characterized by a nominal voltage of 12.66 kV. Additionally, the system has a total active load of 3791.89 kW and a total reactive load of 2694.10 kvar. According to the researchfindings, the total power loss in the original system, in the absence of any DG sources, is measured to be approximately 225.001 kW. In the initial phase of this study, the proposed methodology is applied and evaluated across various scenarios involving the placement of different numbers of DGs. Specifically, the cases considered include the placement of 3 DGs, 4 DGs respectively shown in table 1. Based on the findings, it can be inferred that the strategic positioning of three DGs leads to a decrease in power loss, enhancement of the voltage profile, and improved VSI. Based on the analysis conducted, it has been determined that exceeding a total of 3 DGs is not a viable option for the considered distribution network. Here, it has been observed that the performance of the system tends to degrade when the number of DGs exceeds three shown in Figure 1. The comparison of Voltage Profile and VSI of multiple DGs along with base case is shown in Figures 2 and 3.

Table 1.Comparison of Power loss and Voltage and VSI for various cases.

Possible cases	**Location of Bus Number**	**Sizing of DG in kW**	**The Loss of Power in kW**	**Vmin in p.u.**	**VSImin In p.u.**
Base Case	NA	NA	225.0014	0.9678	0.8773
3 DGs	11 17 61	526.9108 380.4599 1718.921	68.4272	0.9916	0.9666
4 DGs	11 17 21 61	526.5266 203.7865 176.4290 1718.997	69.2495	0.9915	0.9659

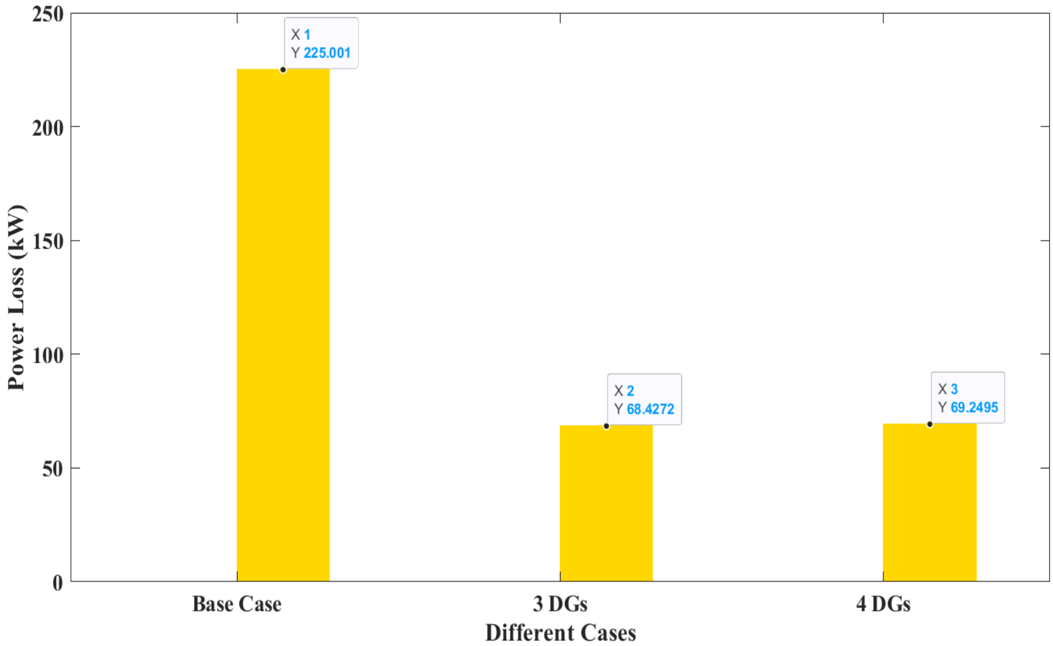

Figure 1. Comparison of power loss with multiple DGs

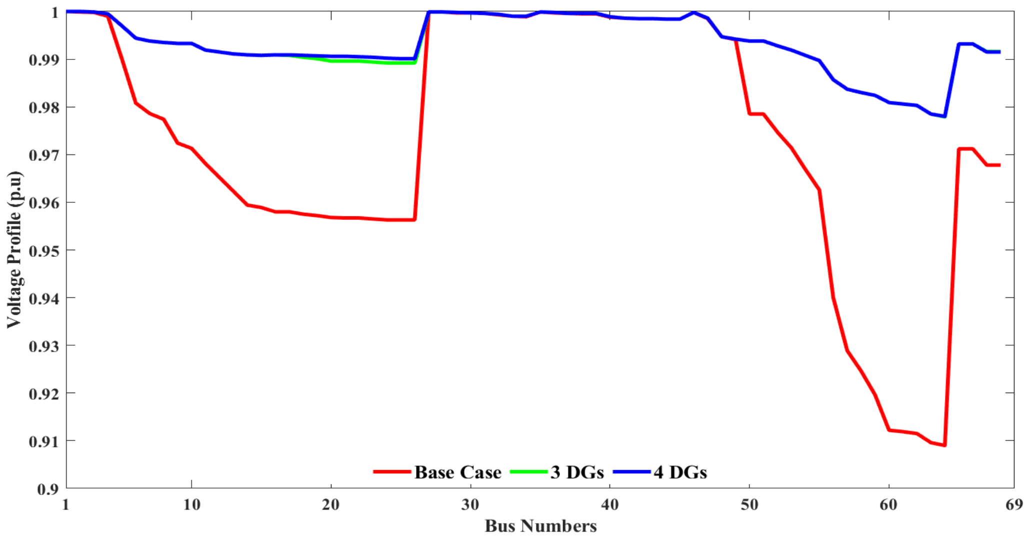

Figure 2. Comparison Voltage profile of multiple DGs with base case

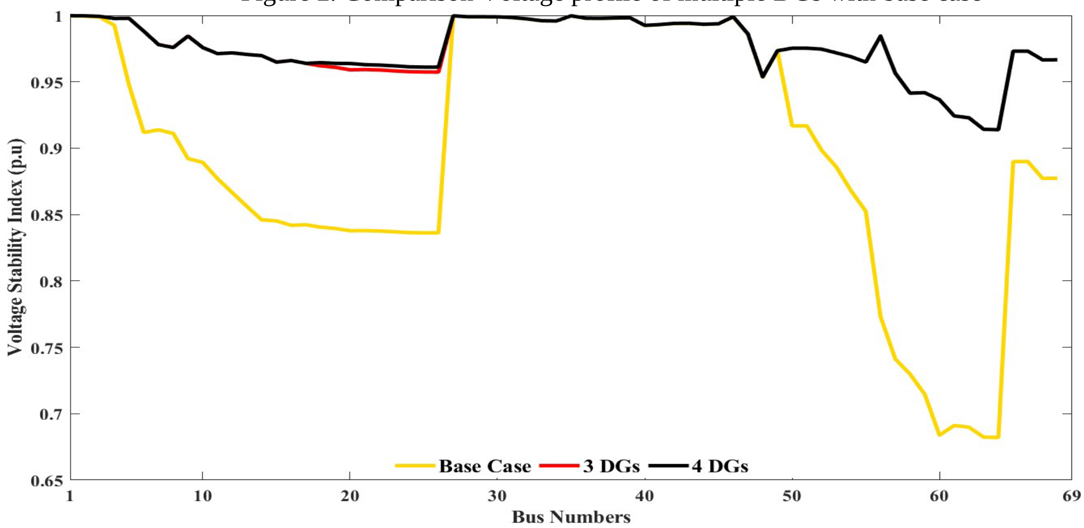

Figure 3. Comparison VSI of multiple DGs with base case

At this point, the analysis process is executed for various load scenarios, including half load conditions (0.5 per unit (p.u.)), full load conditions (1.0 p.u.), and high load conditions (1.1 p.u.), are considered to assess the efficacy of the proposed methodology. The variation in the power loss, with and without DGs that were acquired at various load levels are shown in the table 2. In the instance that the DGs have been placed in appropriate locations and of acceptable sizes, a significant decrease in power loss may be realized across all load levels shown in Figure 4.

Table 2.Comparison of Power loss for various load levels.

Various Load Levels	Without DGs PLoss (kW)	With DGs PLoss (kW)	% of reduced PLoss
Half Load (0.5)	51.6063	17.0435	66.97
Full Load (1.0)	225.0014	68.4272	69.58

Heavy Load (1.1)	277.4523	84.3186	69.60

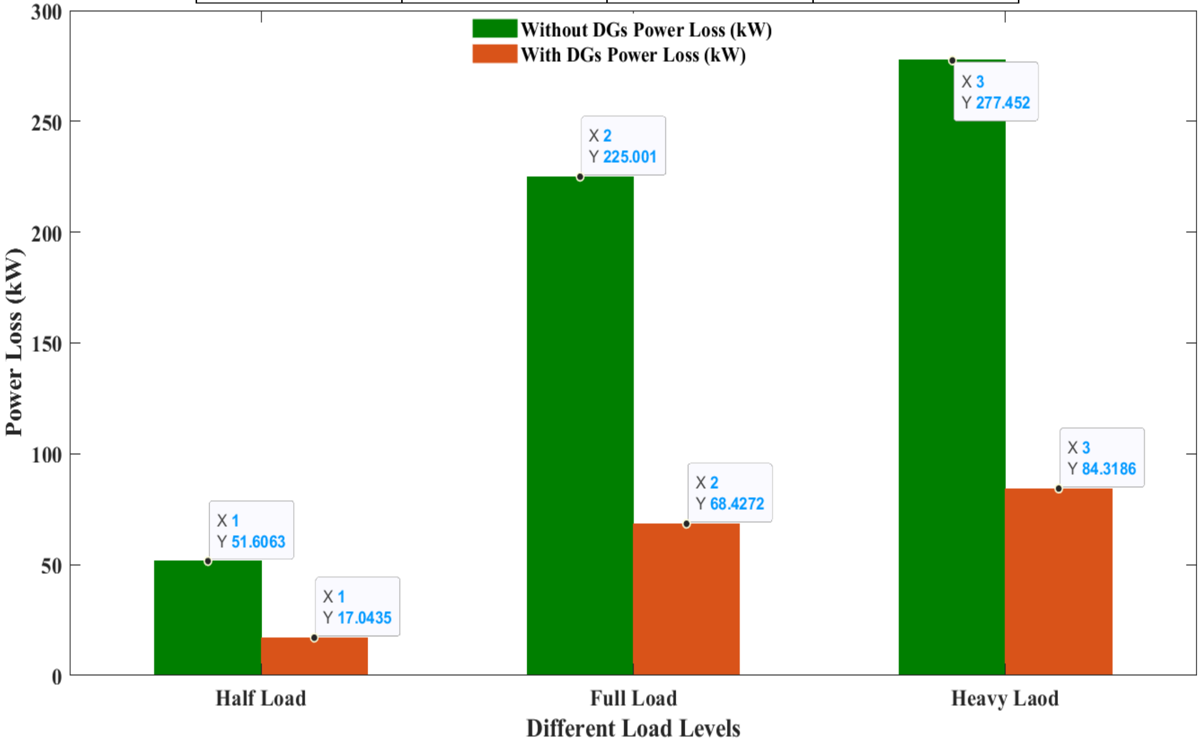

Figure 4. Comparison of power loss on multiple load levels with and without DGs

Additionally, various contemporary optimization approaches are compared to the proposed EGOA to determine its effectiveness and the results are given in table 5.3. It is clear that GOA outperforms all other strategies in minimizing power loss, that prove its effectiveness in comparison to other methods.

Table 3. Comparison of GOA with other existing algorithms

Optimization Method	SIMBO-Q [17]	LSFSA [18]	QOTLBO [19]	Proposed GOA
Size and area of DGs in kW	618.9 529.7 1500.0	420.4 1331.1 429.8	533.4 1198.6 567.2	526.9108 380.4599 1718.921
3 DGs Power Loss in kW	71.3	77	71.625	68.4272
% of reduced Power loss	68.31	65.73	68.17	69.58

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The analysis is extended to evaluate the effects of Electric Vehicles (EVs) under dynamic load conditions, considering a 24-hour load demand, as depicted in Figure 5.

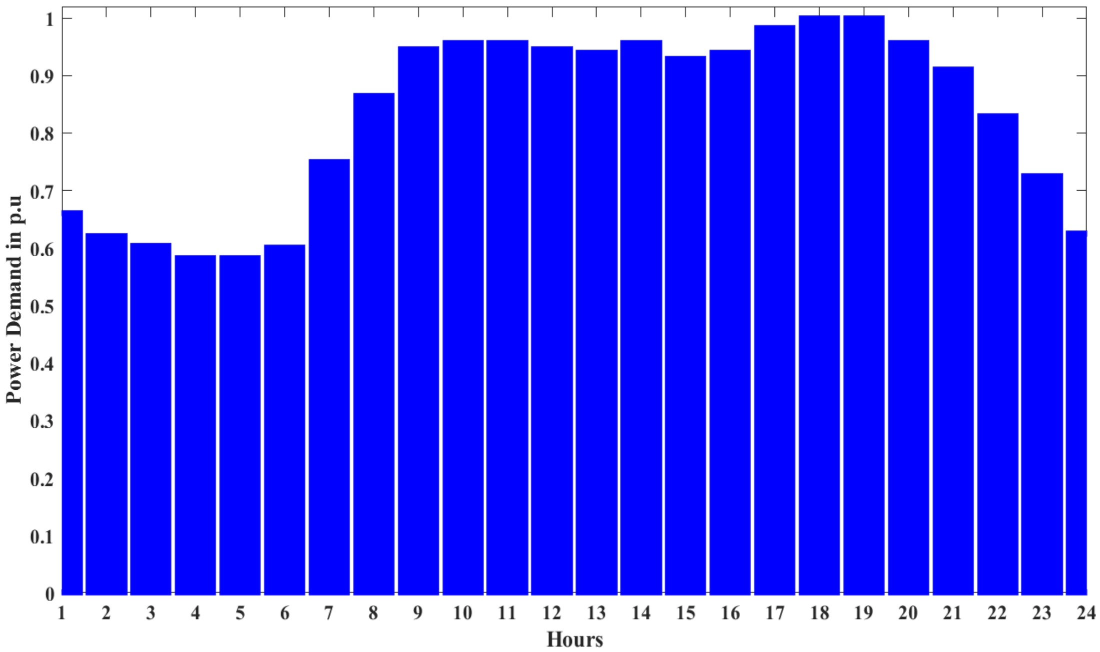

Figure 5 illustrates the Power Demand Curve

The specifications for the Electric Vehicle (EV) are detailed in Table 4.

Table 4 provides the EV specifications and ratings, as referenced from sources [20, 21]

Specifications	**Ratings**
Capacity of the EV or Battery specifications	16 kWh
The count of EVs	60
SoCmin	0.2
SoCmax	0.9
Avg. amount of energy used per km	0.175 kWh/km
Avg. mileage of each EV	30km

The analysis explores the potential of optimizing EV scheduling and highlights the advantages of utilizing three different operating modes for Distributed Generators (DGs).

First Mode: In the dumb charging mode, Electric Vehicles (EVs) are charged using the Grid-to-Vehicle (G2V) method once the battery's State of Charge (SoC) is low, without considering the balance between power supply and demand. This approach prioritizes user convenience. It was observed that when only EVs were connected to the distribution system, power losses increased to 3768.15 kW. However, when both EVs and DGs were positioned together, the losses significantly decreased to 1177.16 kW.

Second Mode: In the smart charging mode, EVs are charged using the G2V method once their SoC is low, but this time, the process is based on real-time availability of power supply and demand. Under this mode, power losses similarly increased to 3768.15 kW when only EVs were connected. When EVs and DGs were placed concurrently, the losses reduced further to 1176.26 kW, showing an improvement over dumb charging.

Third Mode: In this bidirectional mode, EVs are not only charged but can also supply power back to the grid, involving both G2V charging and Vehicle-to-Grid (V2G) discharge. This process operates alongside smart charging, with an intelligent algorithm that schedules optimal charging and discharging times based on current system demand. This mode resulted in the lowest power losses, reducing them to 1174.61 kW.

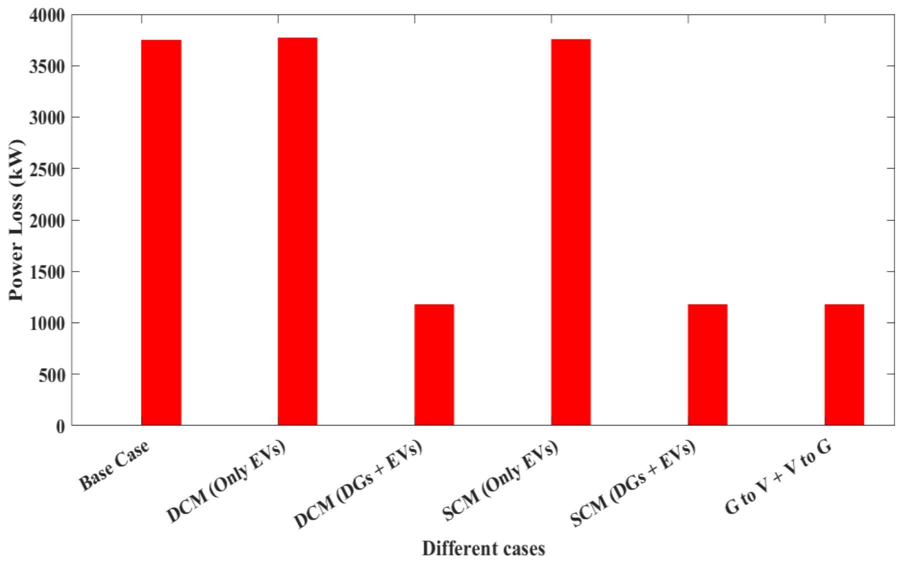

Figure 6.A comparison of power losses across different modes under dynamic load conditions

Figure 5.8 illustrates the comparison of power losses under dynamic load conditions for various operating modes during charging and discharging, utilizing both Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) approaches

Table 5.Comparison of power losses under dynamic load conditions

Different cases		**Power Loss (kW)**
Base Case		3746.2833
Dumb Charging Method	Only EVs	3768.1592
	EVs + DGs	1177.1657
Smart Charging Method	Only EVs	3758.0338
	EVs + DGs	1176.2618
Grid to Vehicle + Vehicle to Grid Method		1174.6143

5. Discussion

The adoption of EVs in the DS is growing rapidly. This article introduces a novel approach for efficiently managing the scheduling of EVs and DGs in a DS. A smart charging method has been developed to effectively reduce peak shaving for EVs' trip patterns and DS demand. The results show that there is a viable option to efficiently decrease peak congestion and, by extension, power loss in the system. In addition, we maximize voltage profile improvement and reduce power loss by determining the appropriate placement and size of DGs. By accounting in EV uncertainty and load circumstances, a comparative evaluation of several EV operating modes is developed. The total performance of the DS may be improved by the efficient scheduling of DGs and EVs. Additionally, it is clear that EV owners have the potential to get revenue in V2G mode provided they are able to plan their EVs according to the consumption pattern of the system. Taking into account the RES's unpredictability and using EVs for reactive power supply could enhance this work in future.

Refrences

1. Julia K. Szinai, Colin J.R. Sheppard, Nikit Abhyankar, Anand R. Gopal, Reduced grid operating costs and renewable energy curtailment with electric vehicle charge management, Energy Policy, Volume 136, 2020, 111051, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2019.111051.

2. Sowmya R, V. Sankaranarayanan, Optimal vehicle-to-grid and grid-to-vehicle scheduling strategy with uncertainty management using improved marine predator algorithm, Computers and Electrical Engineering, Volume 100, 2022, 107949, ISSN 0045-7906, https://doi.org/10.1016/j.compeleceng.2022.107949.

3. Wang, Jianhui & Liu, Cong & Ton, Dan & Zhou, Yan & Kim, Jinho & Vyas, Anant. (2011). Impact of plug-in hybrid electric vehicles on power systems with demand response and wind power. Energy Policy. 39. 4016-4021. 10.1016/j.enpol.2011.01.042.

4. Ma, Yuchao & Houghton, Thomas & Cruden, A. & Infield, David. (2012). Modeling the Benefits of Vehicle-to-Grid Technology to a Power System. IEEE Transactions on Power Systems IEEE TRANS POWER SYST. 27. 1012-1020. 10.1109/TPWRS.2011.2178043.

5. Liansheng Liu, Fanxin Kong, Xue Liu, Yu Peng, Qinglong Wang, A review on electric vehicles interacting with renewable energy in smart grid, Renewable and Sustainable Energy Reviews, Volume 51, 2015, Pages 648-661, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2015.06.036.

6. Jamshid Aghaei, Ali Esmaeel Nezhad, Abdorreza Rabiee, Ehsan Rahimi, Contribution of Plug- in Hybrid Electric Vehicles in power system uncertainty management, Renewable and Sustainable Energy Reviews, Volume 59, 2016, Pages 450-458, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2015.12.207.

7. Wei Wu, Boqiang Lin, Benefits of electric vehicles integrating into power grid, Energy, Volume 224, 2021, 120108, ISSN 0360-5442, https://doi.org/10.1016/j.energy.2021.120108.

8. Hasan Mehrjerdi, Dynamic and multi-stage capacity expansion planning in microgrid integrated with electric vehicle charging station, Journal of Energy Storage, Volume 29, 2020, 101351, ISSN 2352-152X, https://doi.org/10.1016/j.est.2020.101351.

9. Saadatmandi, M., Hakimi, S.M. (2020). Optimal Utilization of Solar Energy for Electric Vehicles Charging in a Typical Microgrid. In: Ahmadian, A., Mohammadi-ivatloo, B., Elkamel, A. (eds) Electric Vehicles in Energy Systems. Springer, Cham. https://doi.org/10.1007/978-3-030- 34448-1_5

10. R. Chen et al., "Two-stage Optimal Charge Control of Plug-in Hybrid Electric Vehicles in a Smart Gird," 2018 Chinese Automation Congress (CAC), Xi'an, China, 2018, pp. 3378-3383, doi: 10.1109/CAC.2018.8623614.

11. Mostafa Rezaei Mozafar, M. Hadi Amini, M. Hasan Moradi, Innovative appraisement of smart grid operation considering large-scale integration of electric vehicles enabling V2G and G2V systems, Electric

Power Systems Research, Volume 154, 2018, Pages 245-256, ISSN 0378-7796, https://doi.org/10.1016/j.epsr.2017.08.024.

12. M. Hadi Amini, Mohsen Parsa Moghaddam, Orkun Karabasoglu, Simultaneous allocation of electric vehicles' parking lots and distributed renewable resources in smart power distribution networks, Sustainable Cities and Society, Volume 28, 2017, Pages 332-342, ISSN 2210-6707, https://doi.org/10.1016/j.scs.2016.10.006.

13. Quirós-Tortós, J., Ochoa, L. F., Alnaser, S. W., & Butler, T. (2015). Control of EV charging points for thermal and voltage management of LV networks. IEEE Transactions on Power Systems, 31(4), 3028-3039.

14. M. H. Amini and A. Islam, "Allocation of electric vehicles' parking lots in distribution network," ISGT 2014, Washington, DC, USA, 2014, pp. 1-5, doi: 10.1109/ISGT.2014.6816429.

15. Z. Min, C. Qiuyu, X. Jiajia, Y. Weiwei and N. Shu, "Study on influence of large-scale electric vehicle charging and discharging load on distribution system," 2016 China International Conference on Electricity Distribution (CICED), Xi'an, China, 2016, pp. 1-4, doi: 10.1109/CICED.2016.7576208.

16. Chakravorty, Mitali & Das, Dibya. (2001). Voltage Stability Analysis of Radial Distribution Networks. International Journal of Electrical Power & Energy Systems. 31. 129-135. 10.1016/S0142-0615(00)00040-5.

17. Sharmistha Sharma, Subhadeep Bhattacharjee, Aniruddha Bhattacharya, Quasi-Oppositional Swine Influenza Model Based Optimization with Quarantine for optimal allocation of DG in radial distribution network, International Journal of Electrical Power & Energy Systems, Volume 74, 2016, Satish Kumar Injeti, N. Prema Kumar,

18. A novel approach to identify optimal access point and capacity of multiple DGs in a small, medium and large scale radial distribution systems, International Journal of Electrical Power & Energy Systems, Volume 45, Issue 1, 2013, Pages 142-151, ISSN 0142-0615, https://doi.org/10.1016/j.ijepes.2012.08.043.

19. Sneha Sultana, Provas Kumar Roy, Multi-objective quasi-oppositional teaching learning based optimization for optimal location of distributed generator in radial distribution systems, International Journal of Electrical Power & Energy Systems, Volume 63, 2014, Pages 534-545, ISSN 0142-0615, https://doi.org/10.1016/j.ijepes.2014.06.031.

20. Dharavat N, Sudabattula SK, Velamuri S, Mishra S, Sharma NK, Bajaj M, Elgamli E, Shouran M, Kamel S. Optimal Allocation of Renewable Distributed Generators and Electric Vehicles in a Distribution System Using the Political Optimization Algorithm. Energies. 2022; 15(18):6698. https://doi.org/10.3390/en15186698

21. Golla NK, Dharavat N, Sudabattula SK, Velamuri S, Kantipudi MVVP, Kotb H, Shouran M and Alenezi M (2023), Techno-economic analysis of the distribution system with integration of distributed generators and electric vehicles. Front. Energy Res. 11:1221901. doi: 10.3389/fenrg.2023.1221901