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Distribution Network Expansion Planning and Integration of Distributed Energy Resources Considering Massive Penetration of Electric Vehicle Charging Stations in Malaysia

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ABSTRACT

By 2030, Malaysia's Low Carbon Mobility Blueprint 2021-2030 anticipates 20,000 Electric Vehicles (EV) in the market. The increase of EV population as transportation due to the environment issue has caused sudden impact to the distribution network system which needs to be tackled urgently. The massive penetration of EVCS into the distribution network system, especially at houses, parking lot and any strategic places either for slow, medium or fast charging, will lead to other crucial issues such as increment of power losses and voltage violations. Hence, Distribution Network Expansion Planning (DNEP) strategies become critical to adhere this issue. Distributed Energy Resources (DERs) with low-carbon efforts are one of the potential sources of power to overcome this issue that have a substantial influence on system reliability and security, particularly in power losses and voltage profiles characteristics. This research paper presents optimal techniques for development of DNEP with integration of DERs towards achieving multi-objectives of minimizing power losses and improving the voltage profiles. These techniques are based on industry-based technical analysis conducted using the Power System Simulator/Advanced Distribution Engineering Productivity Tool (PSS/ADEPT) software. The proposed methods are tested on the realistic 11kV 69-bus radial distribution network. The simulation results successfully demonstrate the effectiveness of the proposed method for DNEP to minimize power losses and voltage profile improvement in the distribution network system due to the massive penetration of EVCS along the 20 years of DNEP horizon in Malaysia.

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1. Introduction

Distribution Network Expansion Planning (DNEP) main goal is to ensure that there is a reliable supply of energy to fulfil customer demand at the lowest cost possible given the nature of the load, in compliance with asset management best practices and in an environmentally responsible manner [1-3]. The key challenge in planning is determining the most cost-effective investment in relation to the anticipated risk of supply reliability or the frequency and impact of breakdowns. Planning methodology is changing to synchronize the active control development in smart-grid applications such Distributed Energy Resources (DERs) [4-6], Electric Vehicle Charging Stations (EVCS) [7,8], Battery Energy Storage Systems (BESS) [9], micro-grids, Capacitor Banks (CBs) [10,11] and many more. The novel approach to DNEP that combines active distribution network capabilities provides more cost-effective solutions through multi-objective [12], probabilistic and risk-oriented planning.

A detailed description of the smart grid [13] with a distribution state estimation measurement system reliant on information and communication technology is one of the main components of the new planning methodologies, along with many other improvements in load and generation representation and increased visibility of time series load and generation profiles. Under the business model of asset management techniques, prudent and sustainable planning seeks to balance performance, cost and risk while aligning the management of asset-related investments with corporate goals [14]. It provides a series of financial choices that can maximize shareholder returns on investment and guarantee that capital expenditures made now will be worthwhile for the duration of their useful lives.

1.1 Review of Related Works

The Active Distribution Networks (ADN) planning challenge is different from the usual DNEP problems in that it addresses the integration of DERs. Loads, storage and generators are just a few of the DERs that may be managed by the ADN distribution system. Notably, ADN lessens the impact of unpredictable renewable resources, improving network performance both during planning and during operation. In order to assess the effect of various DGs configurations, they put out a multi-configuration multi-period optimum power flow approach [15]. A long-term dynamic planning of DGs taking active management into account which produced separate DNEPs [16]. To manage the output power of DGs, researcher initially increased the network's assets before introducing a real-time tractable iterative AC OPF [17].

The utility planning approach for the DNEP was proposed where two-step strategy that has been presented extends network assets in the first stage and takes network operation into account in the second. In these article, planning and operation levels are examined separately whereas an integrated framework is necessary [18]. ADN planning model for multiple-stage, multiple-load scenarios have been proposed [19]. While network reconfiguration and DGs dispatch are dealt with in the operating problem, the network assets are enlarged in planning. The ambiguity of resources is not addressed, though. The planning of a cooperative multistage distribution network that takes into account active resource management is presented [20]. Distribution system operator (DSO) seeks to reduce investment and operational expenses related to planning and operation levels in the proposed.

2. Methodology

In this research, the main topic to be examined is DNEP considering massive penetration of EVCS along the 20 years planning horizon of DNEP in Malaysia. In this research, normal load growth of 2% per year and EVCS are the main source of power losses and voltage volatility injection to the distribution network system. Integration of DERs will be introduced later in order to produce optimal DNEP with reduction of power losses and voltage drop due to the massive penetration of EVCS. The objectives of DNEP in this research are to reduce power losses and comply with the voltage profile constraint. The research will consider the medium voltage distribution network system. In order to setup this research, Power System Simulator/Advanced Distribution Engineering Productivity Tool (PSS/ADEPT) software will be used.

The methodology sections will concentrate on presenting the research framework, which will describe the general procedure of this research, as illustrated in Figure 1. This research will start with distribution network system, EVCS and DERs modelling for the purposes of load profile modelling and load flow analysis [21] to determine the power losses and voltage profile analysis. Following that, load forecasting will be carried out for 20 years planning horizon. Then, based on the voltage profile [22] from the existing distribution network system, the arrangement for DERs dedicated to medium voltage systems will be integrated in the distribution network system in order to find the optimal reduction of power losses [23] and to improve voltage profiles for the DNEP's 20-year planning horizon.

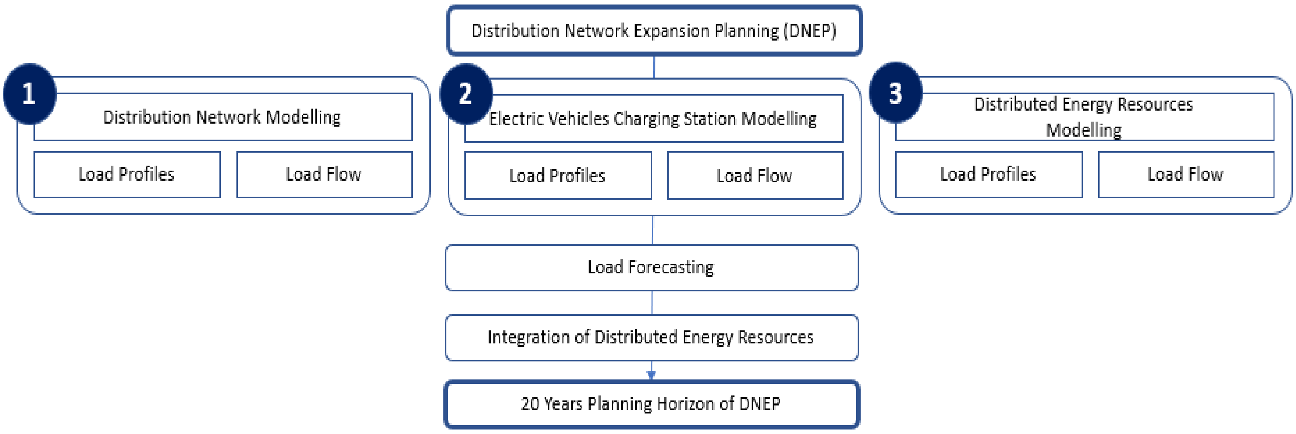

Fig. 1. Research framework to introduce distribution network expansion planning

2.1 Modelling of Distribution Network System

Figure 2 depicts the single line schematic for the realistic 11kV 69-bus radial distribution network [24] system used in this study. This distribution network system is made up of 6 feeders and 69 buses. The primary sources of this distribution network system are from the grid through 132/33kV and 33/11kV distribution transformer. Firstly, the existing distribution is modelled by using PSS/ADEPT software to obtain the preliminary results of power losses and voltage profiles. The existing distribution network system has been forecasted to accommodate normal load growth of 2& yearly as well as massive penetration of EVCS.

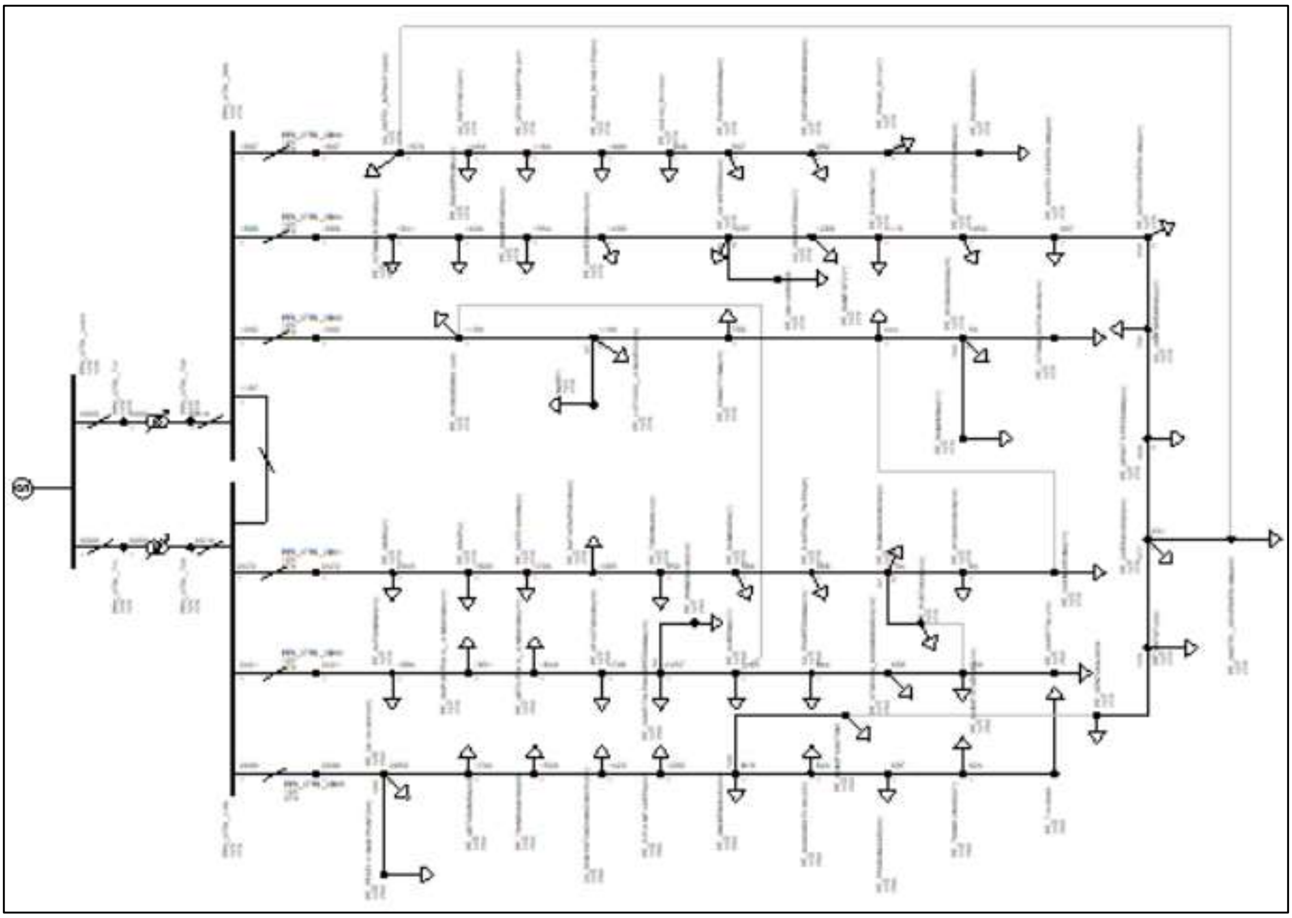

Fig. 2. 11kV 69-bus distribution network system

2.2 Modelling of Electric Vehicle Charging Station

SAE Standards [25] for charger types will be employed in this research for EVCS modelling. Table 1 details the power for the EVCS that will be used in this investigation. The time it takes to fully charge an EV at level 1 (slow charging) is between 6 and 14 hours. The time required to completely charge the EV at level 2, which is medium charging, is 3 to 4 hours. The time needed to fully charge the EV with level 3 quick charging is between 20 and 30 minutes. Realistic measurements have been used to scale down the injection of EVCS loads into the distribution network to 1 MVA and 11 kV per unit.

Table 1
Details of electric vehicle charging station based on SAE standard

Charger Type	Real Power	Reactive Power
Level 1	1.92 kW	0.60 kVAr
Level 2	19.2 kW	5.99 kVAr
Level 3	120 kW	37.44 kVAr

2.3 Modelling of Distributed Energy Resources

Malaysia now prioritizes diversifying its resource base to fulfil growing energy demand while preserving energy security. The nation's total primary energy supply has increased at an average annual rate of 3% over the past ten years, with fossil fuels predominating in the energy mix [26]. The effects of deploying DERs on active and reactive power losses are determined by the quantity of DERs installed and the ratings of the output power pattern [27]. The technology utilized to create the plant, as well as the design of both active and reactive power generation to the distribution system, determine the characteristics of each solar DER. The DERs were modelled to produce either active or reactive electricity based on their technical features. Because this study focuses solely on power loss and voltage profile, all DERs will produce only active power and will be assumed to have a power factor of unity. The placement and sizing of DERs will be determined by the bus's greatest losses and the voltage profile at the bus.

3. Distribution Network Expansion Planning (DNEP)

In DNEP, load Forecasting [28] is important planning research that is used to forecast future power demand or sales growth. Forecasts that are accurate, trustworthy and defendable will assist planners in making sensible investment decisions for system extension, reinforcement and new plant-up to meet rising demand. The horizon of demand forecast could be short, medium or long-term depending on the uses of the forecast. According to the Distribution Code, the prediction horizons for DNEP are as follows: short term (1 - 2 years), medium term (2 - 5 years) and long term (6 - 20 years). According to the Planned Energy Scenario (PES), Malaysia's final energy consumption would double by 2050, with energy demand increasing 2.0% yearly on average [26].

3.1 Objective Functions in DNEP

Power loss [29] and voltage profile are the two objective functions that are the focus of this research for DNEP purposes. Two buses are connected to a cable or overhead wire in the majority of distribution systems. Eq. (1) and Eq. (2) provide a theoretical representation of the power loss [30].

$$S_{loss} = \sum_{l}^{n} V_{i,l} I_{ij,l}^{*} + V_{j,l} I_{ji,l}^{*} \tag{1}$$

$$P_{loss} = real\ (S_{loss}) \tag{2}$$

Where,
S_{loss} - Apparent power losses
P_{loss} - Real power losses
$V_{i,l}$ - Local voltage at *l*th line
$V_{j,l}$ - Remote voltage at *l*th line
$I_{ij,l}^{*}$ - Current flow from local to remote lth line
$I_{ji,l}^{*}$ - Current flow from remote to local at lth line
n - Total number of lines

The formula given by Nasir *et al.,* [31] can be used to determine the voltage profile at each buss. This equation is shown in Eq. (3). The requirement that all bus voltages stay within a specific range represents the second optimization constraint [32]. The acceptable voltage range is between 0.95 and 1.05 pu.

$$V_{profile} = \sum_{l}^{n} (V_i - V_{nom}) \tag{3}$$

Where,
V_i – the bus voltage i in pu
V_{nom} – the nominal voltage in pu
n – the number of buses

3.2 Industry-Based Technical Analysis using PSS/ADEPT for DNEP

This research focuses on two main industry-based technical analysis using PSS/ADEPT for the purpose of development of the optimal DNEP along the 20 years planning horizon. The first technical analysis involves the analysis of the impact of massive penetration of EVCS in the realistic 11kV 69-bus radial in DNEP throughout the planning horizon. The second part of the analysis is to develop an optimal DNEP with the integration of DERs by optimizing its sizes and placement in the existing distribution network system. The proposed size and location placement for integration of DERs are based on the feeder with voltage violations and bus with the highest power losses.

4. Results

The expected results and outcomes in this research are to minimize the power losses and improve voltage profiles in distribution network system due to the massive penetration of EVCS loads along the 20 years DNEP horizon in Malaysia. The details of the expected results and outcomes will be discussing further in the next subtopic accordingly.

4.1 Load Forecasting for 20 Years Planning Horizon of DNEP

In this research, load forecast for 20 years DNEP horizon is made based on 2% annually electricity growth projection. Table 2 presented the load forecast in term of peak load demand in kilowatts (kW) of 69-bus practical distribution network for 20 years planning horizon in Malaysia from 2023 up to 2042 together with power losses in kW produced by the existing distribution network before installing any EVCS.

Table 2
Load forecast of 69-bus practical distribution network for 20 years planning horizon

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Peak Load Demand (kW)	11,125	11,351	11,582	11,818	12,058	12,304	12,554	12,810	13,071	13,337
Losses (kW)	157	164	171	178	186	194	202	211	220	229
	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Peak Load Demand (kW)	13610	13887	14171	14460	14756	15058	15366	15680	16001	16329
Losses (kW)	239	250	261	272	284	296	309	322	336	351

Meanwhile based on load forecast, Figure 3 show the voltage profiles comparison between year 2023 and year 2042 for the existing distribution network without any upgrading project. All the voltages are within the allowable voltage limit of 0.95 – 1.05 pu.

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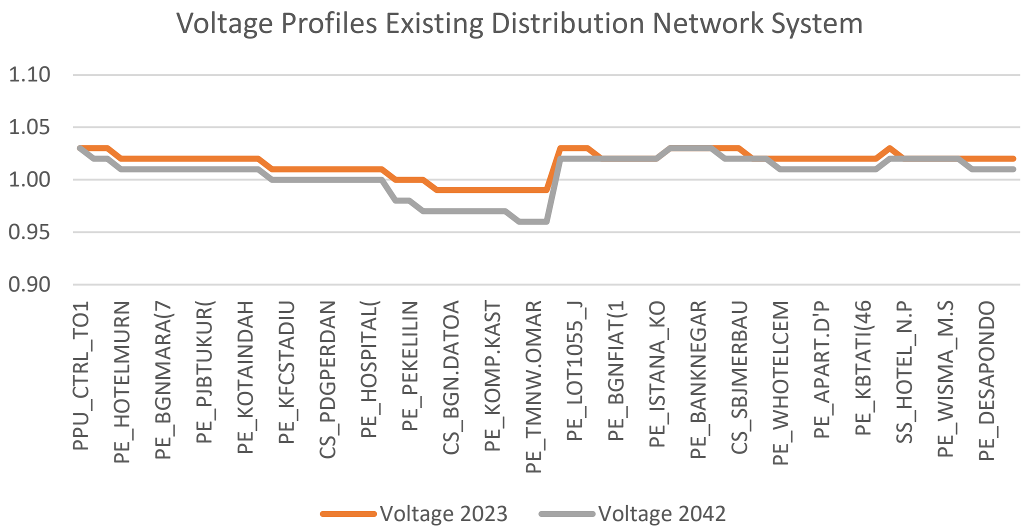

Fig. 3. Voltage profiles on existing and forecasted load in distribution network

4.2 Load Forecasting for 20 Years Planning Horizon of DNEP with Massive Penetration of EVCS

Up to 2050, Malaysia's total power demand is expected to increase by 2% per year. This increase is accelerated by electrification, reaching 2.6% yearly [26]. Figure 4 illustrates the rise in power consumption from 2018 to 2050 by industry and scenario. Transportation sector shows an exponentially increase in electricity demand due to the increase of green mobility which directly increase the number of EVCS in the market. As of November 2023, there are 1,430 EVCS in Malaysia and 303 from the total EVCS are from DC Fast Charger [33]. As outline in 2021 under Low Carbon Mobility Blueprint (LCMB) 2021-2030, Malaysia is aiming to have 10,000 EVCS in place by 2025 [34]. Hence, in this research, the massive penetration of EVCS into existing distribution network will be focused in order to develop a comprehensive DNEP along the 20 years of planning horizon in Malaysia.

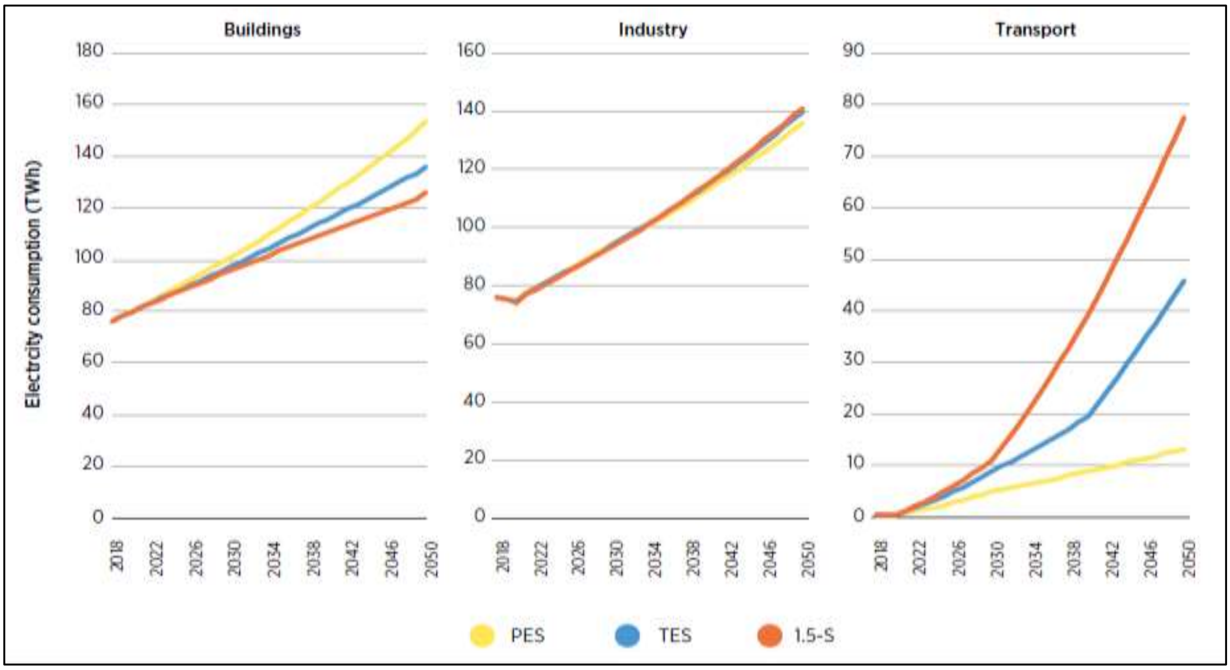

Fig. 4. Electricity demand growth by sector and scenario [20]

Five scenarios have been carried out in this research which EVCS detail placement for all scenarios will be in year 2023, 2027, 2032, 2037 and 2042 respectively as shown in Table 3 below. The placements consist of combination from Fast Charger (Level 3), Medium Charger (level 2) and Slow Charger (Level1). From the results, the massive penetration of EVCS directly contribute to the increment of the power losses in the existing distribution network.

Table 3
EVCS detail placement for all scenarios

Year	No. of CS Level 3	No. of CS Level 2	No. of CS Level 1	Total EVCS	EVCS Load (MW)	EVCS Load (MVAr)	Power loss (MW)
2023	20	30	80	2,153	3,125	1,936	251
2027	29	44	117	2,217	4,545	2,816	367
2032	47	71	189	2,339	7,352	4,556	540
2037	76	114	304	2,531	11,877	7,360	1,026
2042	122	183	489	2,837	19,096	11,834	1,772

Table 4 shows a power losses comparison before and after the massive penetration of EVCS into the existing distribution network system. The power losses increment is ranging from 60% up to 405%.

Table 4
Power losses comparison for all scenarios

Year	2023	2027	2032	2037	2042
Peak Load Demand without EVCS (kW)	11125	12058	13337	14756	16329
Losses (kW)	157	186	229	284	351
Peak Load Demand with EVCS (kW)	14345	17035	21176	27375	36847
Losses (kW)	251	367	540	1026	1772
% losses increase	60%	97%	136%	261%	405%

From the results, there are no voltage violation in scenario year 2023, 2027 and 2032. Meanwhile, Figure 5 and 6 show that for the year 2037 and 2042, the voltage profile of existing distribution network system have been violated from the allowable limit of 0.95 pu to 1.05 pu. Hence, mitigation need to be done to ensure that the voltage profiles are within the allowable limit. In this research, the mitigation is to integrate DERs in the existing distribution network system.

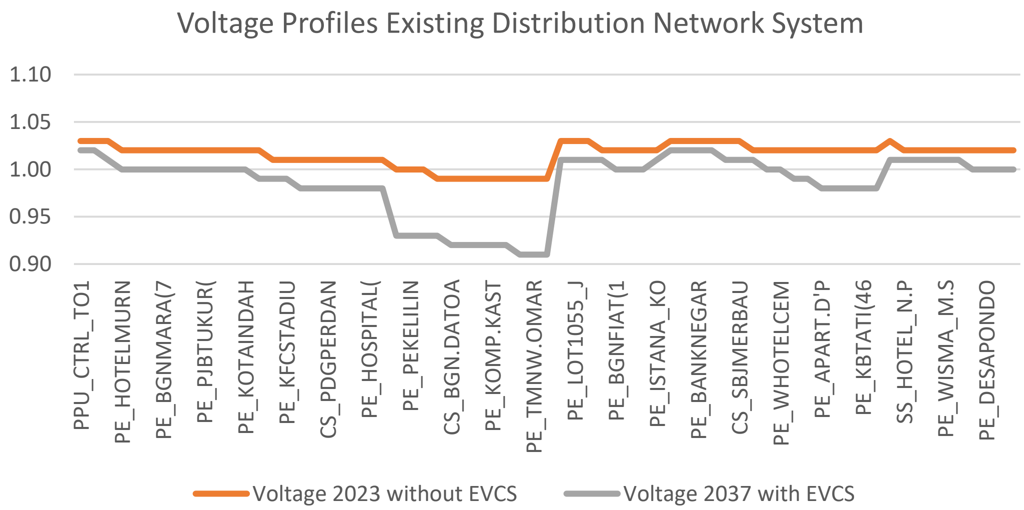

Fig. 5. Voltage profile of existing distribution network in 2023 without EVCS vs in 2037 with EVCS

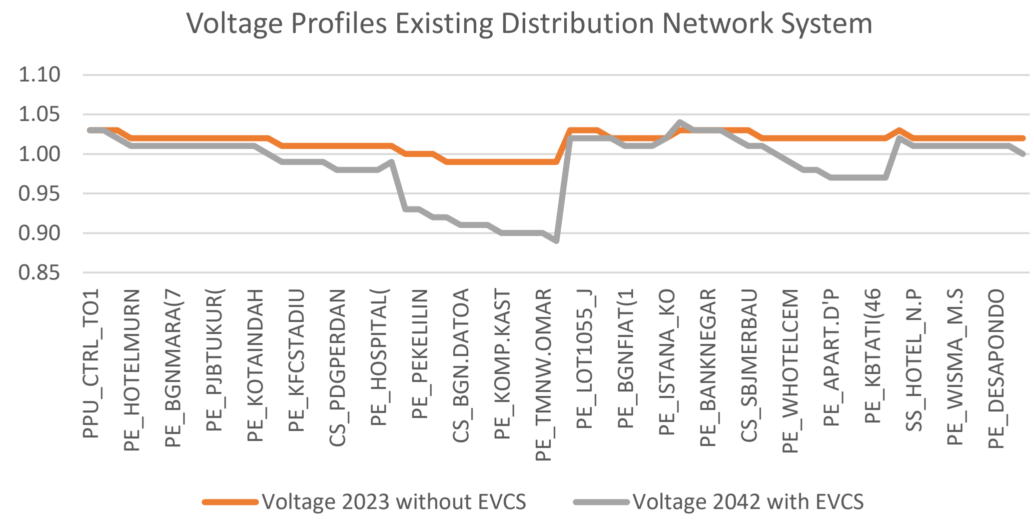

Fig. 6. Voltage profile of existing distribution network in 2023 without EVCS vs in 2042 with EVCS

4.3 DG Integration on the Upgraded Existing Network

The demand of the local distribution network system must be the limiting factor for the total capacity of DERs generation linked to a Medium Voltage (MV) Distribution Network System. 50% of the cable capacity from the interconnection point to the source or 2 MW, whichever is lower, is the proposed acceptable maximum MV penetration limit in this research, which is based on the MV connection points at 11kV substations.

In order to reduce the active power losses in the distribution system, the first simulation is to ascertain the range size of solar DERs linked to the system. Since the DNEP has a dynamic peak load based on both regular load growth and additional major load growth throughout the planned horizon, the number of DERs is dynamic. The outcome demonstrates that the optimal solar size range is between 0.5 and 2 MW. Based on existing simulation in year 2037 and 2042 with massive penetration of EVCS, the power loss is registered at 1,026 kW and 1,772 kW respectively for system without DERs. Table 5 and Table 6 show reduction of power losses in existing distribution network system for DNEP with massive penetration of EVCS and integration of DERs.

Table 5
DNEP integration with DERs for year 2037

No.	Number of DERs	Bus	Size (MW)	Power Losses (kW)	Voltage violation
1	0	-	0	1,026	Yes
2	1	PE SK Islah	1.5-2.0	888	Yes
3	2	PE SK Islah & PE Tanjung Mas	1.5-2.0	774	No

Table 6
DNEP integration with DERs for year 2042

No.	Number of DERs	Bus	Size (MW)	Power Losses (kW)	Voltage violation
1	0	-	0	1,772	Yes
2	1	PE SK Islah	2.0	1,564	Yes
3	2	PE SK Islah & PE Tanjung Mas	2.0	1,413	Yes
4	3	PE SK Islah, PE Tanjung Mas & PE Che Basimah	1.0	1,316	No

By integrating two units of DERs into the DNEP with massive penetration of EVCS in year 2037, power losses reduce from 1,026 kW to 774 kW (25% losses reduction) with no voltage limit violation as per Figure 7 below.

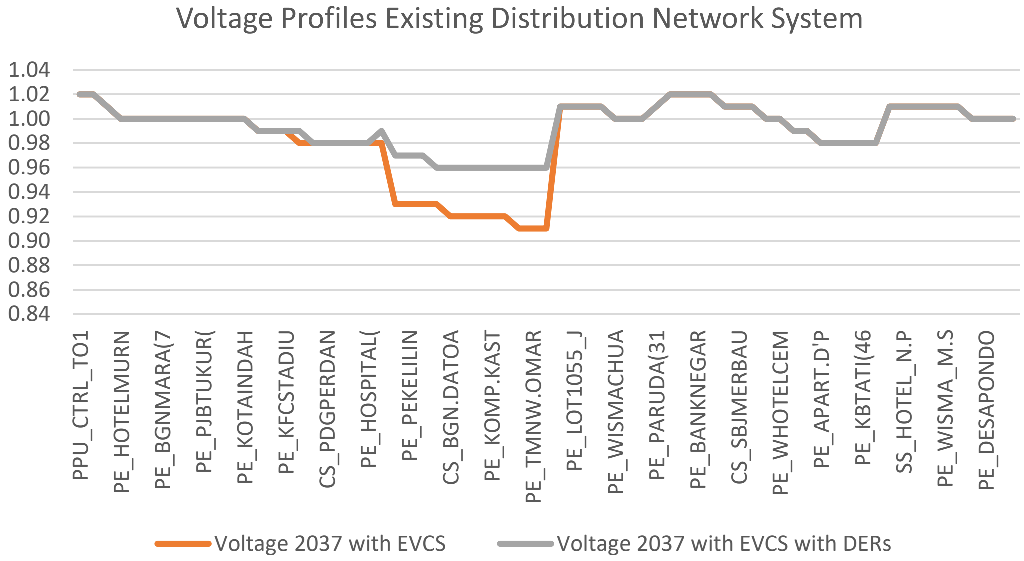

Fig. 7. Voltage profile of existing distribution network considering EVCS in 2037 without DERs vs in 2037 with DERs integration

Meanwhile, by integrating for units of DERs into the DNEP with massive penetration of EVCS in year 2042, power losses reduce from 1,772 kW to 1,316 kW (25% losses reduction) with no voltage limit violation as per Figure 8 below. Integrating DERs in distribution network system can be effective method to reduce power losses and improve voltage profiles and certainly, it is made positive impact to DNEP along the 20 years planning horizon.

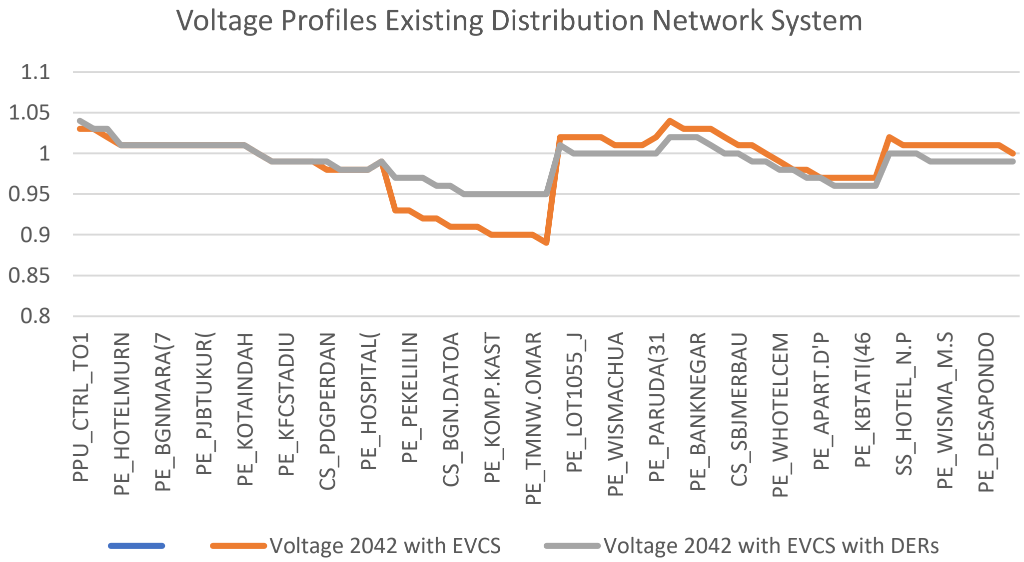

Fig. 8. Voltage profile of existing distribution network considering EVCS in 2042 without DERs vs in 2042 with DERs integration

5. Conclusions

This research paper exhibits successful development of a method to minimize power losses and voltage profile improvement in the distribution network system for realistic 11kV 69-bus radial distribution network due to the massive penetration of EV Charging Station along the 20 years of DNEP horizon. Integration of DERs with correct sizing and placement have been adopted in this research to minimize the power losses and voltage profile improvement in the distribution network system. The design of DERs is based on needs of the specified distribution network system. For the future works, integration of Capacitor Banks into DNEP considering massive penetration of EVCS will be carried out to further improve the performance of existing distribution network system. In addition, meta-heuristic technique [35-37] will be adopted based on its ability to optimize the multi-objective in this research.

Acknowledgement
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References
[1] Verma, Mandhir Kumar, Vinod Kumar Yadav and V. Mukherjee. "Objective functions of distribution network expansion planning-a comprehensive and exhaustive review." In *IOP Conference Series: Materials Science and Engineering*, vol. 594, no. 1, p. 012016. IOP Publishing, 2019. https://doi.org/10.1088/1757-899X/594/1/012016

[2] Kabirifar, Milad, Mahmud Fotuhi-Firuzabad, Moein Moeini-Aghtaie and Niloofar Pourghaderia. "Joint distributed generation and active distribution network expansion planning considering active management of network." In *2019 27th Iranian Conference on Electrical Engineering (ICEE)*, pp. 702-708. IEEE, 2019. https://doi.org/10.1109/IranianCEE.2019.8786665

[3] Kumar, Chauhan Rajeev and Maurya Sanjay Kumar. "An approach of multistage distribution system network expansion planning considering investment, operational cost and reliability of system." *Indian J. Sci. Technol* 13, no. 30 (2020): 2125-2140. https://doi.org/10.17485/IJST/v13i30.678

[4] Ayalew, Mulusew, Baseem Khan, Issaias Giday, Om Prakash Mahela, Mahdi Khosravy, Neeraj Gupta and Tomonobu Senjyu. "Integration of renewable based distributed generation for distribution network expansion planning." *Energies* 15, no. 4 (2022): 1378. https://doi.org/10.3390/en15041378

[5] Bagheri, A., H. Monsef and H. Lesani. "Integrated distribution network expansion planning incorporating distributed generation considering uncertainties, reliability and operational conditions." *International Journal of Electrical Power & Energy Systems* 73 (2015): 56-70. https://doi.org/10.1016/j.ijepes.2015.03.010

[6] Jeddi, Babak, Vahid Vahidinasab, Parviz Ramezanpour, Jamshid Aghaei, Miadreza Shafie-khah and João PS Catalão. "Robust optimization framework for dynamic distributed energy resources planning in distribution networks." *International Journal of Electrical Power & Energy Systems* 110 (2019): 419-433. https://doi.org/10.1016/j.ijepes.2019.03.026

[7] Singh, Bindeshwar and Pankaj Kumar Dubey. "Distributed power generation planning for distribution networks using electric vehicles: Systematic attention to challenges and opportunities." *Journal of Energy Storage* 48 (2022): 104030. https://doi.org/10.1016/j.est.2022.104030

[8] Taljegard, Maria, Lisa Göransson, Mikael Odenberger and Filip Johnsson. "Impacts of electric vehicles on the electricity generation portfolio–A Scandinavian-German case study." *Applied Energy* 235 (2019): 1637-1650. https://doi.org/10.1016/j.apenergy.2018.10.133

[9] Masoumi-Amiri, S. Mahyar, Majid Shahabi and Taghi Barforoushi. "Interactive framework development for microgrid expansion strategy and distribution network expansion planning." *Sustainable Energy, Grids and Networks* 27 (2021): 100512. https://doi.org/10.1016/j.segan.2021.100512

[10] Pinto, Rafael S., Clodomiro Unsihuay-Vila and Fabricio H. Tabarro. "Coordinated operation and expansion planning for multiple microgrids and active distribution networks under uncertainties." *Applied Energy* 297 (2021): 117108. https://doi.org/10.1016/j.apenergy.2021.117108

[11] Sirjani, Reza. "Optimal capacitor placement in wind farms by considering harmonics using discrete lightning search algorithm." *Sustainability* 9, no. 9 (2017): 1669. https://doi.org/10.3390/su9091669

[12] Gholami, Khalil, Shahram Karimi and Amjad Anvari-Moghaddam. "Multi-objective stochastic planning of electric vehicle charging stations in unbalanced distribution networks supported by smart photovoltaic inverters." *Sustainable cities and society* 84 (2022): 104029. https://doi.org/10.1016/j.scs.2022.104029
[13] Nejadfard-Jahromi, Saeed, Masoud Rashidinejad and Amir Abdollahi. "Multistage distribution network expansion planning under smart grids environment." *International Journal of Electrical Power & Energy Systems* 71 (2015): 222-230. https://doi.org/10.1016/j.ijepes.2015.02.021
[14] Esmaeili, Mobin, Mostafa Sedighizadeh and Masoud Esmaili. "Multi-objective optimal reconfiguration and DG (Distributed Generation) power allocation in distribution networks using Big Bang-Big Crunch algorithm considering load uncertainty." *Energy* 103 (2016): 86-99. https://doi.org/10.1016/j.energy.2016.02.152
[15] Al Kaabi, Sultan S., H. H. Zeineldin and Vinod Khadkikar. "Planning active distribution networks considering multi-DG configurations." *IEEE Transactions on Power Systems* 29, no. 2 (2013): 785-793. https://doi.org/10.1109/TPWRS.2013.2282343
[16] Abapour, Saeed, Kazem Zare and Behnam Mohammadi-Ivatloo. "Dynamic planning of distributed generation units in active distribution network." *IET Generation, Transmission & Distribution* 9, no. 12 (2015): 1455-1463. https://doi.org/10.1049/iet-gtd.2014.1143
[17] Karagiannopoulos, Stavros, Petros Aristidou and Gabriela Hug. "Co-optimisation of planning and operation for active distribution grids." In *2017 IEEE Manchester PowerTech*, pp. 1-6. IEEE, 2017. https://doi.org/10.1109/PTC.2017.7981112
[18] Mansor, Nurulafiqah Nadzirah and Victor Levi. "Integrated planning of distribution networks considering utility planning concepts." *IEEE Transactions on Power Systems* 32, no. 6 (2017): 4656-4672. https://doi.org/10.1109/TPWRS.2017.2687099
[19] Shen, Xinwei, Mohammad Shahidehpour, Shouzhen Zhu, Yingduo Han and Jinghong Zheng. "Multi-stage planning of active distribution networks considering the co-optimization of operation strategies." *IEEE Transactions on Smart Grid* 9, no. 2 (2016): 1425-1433. https://doi.org/10.1109/TSG.2016.2591586
[20] Kabirifar, Milad, Mahmud Fotuhi-Firuzabad, Moein Moeini-Aghtaie and Niloofar Pourghaderia. "Joint distributed generation and active distribution network expansion planning considering active management of network." In *2019 27th Iranian Conference on Electrical Engineering (ICEE)*, pp. 702-708. IEEE, 2019. https://doi.org/10.1109/IranianCEE.2019.8786665
[21] Eid, Ahmad, Salah Kamel, Hossam M. Zawbaa and Mostafa Dardeer. "Improvement of active distribution systems with high penetration capacities of shunt reactive compensators and distributed generators using Bald Eagle Search." *Ain Shams Engineering Journal* 13, no. 6 (2022): 101792. https://doi.org/10.1016/j.asej.2022.101792
[22] Sabah, F. T., T. Labuan and N. Berhad. "Distribution Code for Peninsular Malaysia." *T.% 20Labuan% 20Amendments% 202017_V5. pdf#:~: text= The% 20amendments% 20of% 20the% 20Distribution, other% 20distributed% 20generation% 20into% 20the* (2017).
[23] López, Kevin, Walter Mariscal, Juan Plazarte and Javier Urquizo. "Allocation and Optimal Sizing of Flexible Capacitor Banks for the Minimization of Active Power Losses in Long Unbalanced Rural Medium Voltage Distribution Feeders using Heuristic Algorithms." In *2021 22nd IEEE International Conference on Industrial Technology (ICIT)*, vol. 1, pp. 559-566. IEEE, 2021. https://doi.org/10.1109/ICIT46573.2021.9453500
[24] Muthukumar, K. and S. Jayalalitha. "Optimal placement and sizing of distributed generators and shunt capacitors for power loss minimization in radial distribution networks using hybrid heuristic search optimization technique." *International Journal of Electrical Power & Energy Systems* 78 (2016): 299-319. https://doi.org/10.1016/j.ijepes.2015.11.019
[25] International Electrotechnical Commission, ed. *Electric Vehicle Conductive Charging System IEC 61851-1: General Requirements. Exigences Générales*. IEC, 2017.
[26] IRENA. “Malaysia Energy Transition Outlook.” *International Renewable Energy Agency*, Abu Dhabi, (2023).
[27] Pinto, Rafael S., Clodomiro Unsihuay-Vila and Thelma SP Fernandes. "Multi-objective and multi-period distribution expansion planning considering reliability, distributed generation and self-healing." *IET Generation, Transmission & Distribution* 13, no. 2 (2019): 219-228. https://doi.org/10.1049/iet-gtd.2018.5037
[28] He, Jun, Xiao Ling Yang, ChangHong Deng, GuoGang Liu, WenTao Huang and LiWen Zhu. "Expansion planning of electric vehicle charging stations considering the benefits of peak-regulation frequency modulation." *IET Generation, Transmission & Distribution* 16, no. 7 (2022): 1400-1415. https://doi.org/10.1049/gtd2.12376
[29] Satrio, Reza Indra and Subiyanto Subiyanto. "Reduction technique of drop voltage and power losses to improve power quality using ETAP Power Station simulation model." In *AIP Conference Proceedings*, vol. 1941, no. 1. AIP Publishing, 2018. https://doi.org/10.1063/1.5028088
[30] Nasir, SN Syed, WY Wan Yusoff, J. J. Jamian and R. Ayop. "Reducing power loss considering massive charging station using metaheuristic technique." In *2021 IEEE Conference on Energy Conversion (CENCON)*, pp. 169-173. IEEE, 2021. https://doi.org/10.1109/CENCON51869.2021.9627265

[31] Nasir, SN Syed, A. F. Othman, R. Ayop and J. J. Jamian. "Power loss mitigation and voltage profile improvement by optimizing distributed generation." In *Journal of physics: conference series*, vol. 2312, no. 1, p. 012023. IOP Publishing, 2022. https://doi.org/10.1088/1742-6596/2312/1/012023

[32] Imani, Mahmood Hosseini, Payam Niknejad and M. R. Barzegaran. "Implementing Time-of-Use Demand Response Program in microgrid considering energy storage unit participation and different capacities of installed wind power." *Electric Power Systems Research* 175 (2019): 105916. https://doi.org/10.1016/j.epsr.2019.105916

[33] Lim, Anthony. "EV chargers in Malaysia." *Paultan.org*, (2023). https://paultan.org/2023/11/02/ev-chargers-in-malaysia-now-at-1430-total-303-dcfc

[34] Ministry of Environment and Water(KASA). "Low Carbon Mobility Blueprint 2021 – 2030." *Putrajaya, Malaysia*, (2021)

[35] Mohamad, Muhammad Arif and Muhammad Aliif Ahmad. "Handwritten Character Recognition using Enhanced Artificial Neural Network." *Journal of Advanced Research in Computing and Applications* 36, no. 1 (2024): 1-9. https://doi.org/10.37934/arca.36.1.19

[36] Ali, Mirna Fouad, Eman Beshr, Almoataz Y. Abdelaziz and Mohamed Ezzat. "Hybrid Siting and sizing of distributed generators and shunt capacitors with system reconfiguration using wild horse optimizer." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 38, no. 2 (2024): 196-213. https://doi.org/10.37934/araset.38.2.196213

[37] Gaddam, Venkata Anjani Kumar and Manubolu Damodar Reddy. "TLBO trained an ANN-based DG integrated Shunt Active Power Filter to Improve Power Quality." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 43, no. 2 (2025): 93-110. https://doi.org/10.37934/araset.43.2.93110