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Geo-Spatial Analysis of Placement Scenarios and Hosting Capacities for RE-Solar & EV-Charging Infrastructure: A Study in Kerala Distribution Network

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Abstract

The rapid growth of renewable energy (RE)at the distribution level, particularly solar PV rooftops and electric vehicles (EVs). is altering electricity load demand patterns and posing new challenges for distribution network planning. Increased solar penetration and EV charging demand have already intensified peak demand and may be straining the existing grid network.

In Kerala, India, these initiatives have already caused low-tension fuse blowouts, distribution transformer failures, power outages, voltage instability, and feeder overloading at the 11kV level, along with increased operational costs. This study evaluates the integration of EV charging units and solar PV at the distribution network in the Cheranellure section of Ernakulam district. It mainly focused on two feeders, Pachalam and Periyar. A detailed power system model was developed using Python for Power System Analysis (PyPSA), accounting for network connections, transformer capacities, feeder-level load profiles, and prevailing solar installed capacities. The methodology integrates load flow analysis with the geospatial locations of network components. This enables the simulation of different scenarios that consider the hosting capacities of solar RE and EV charging units, at distribution transformer (DT) and feeder ratings. The results indicate that several DTs can accommodate 20-40 kW of additional rooftop solar capacity, depending on the DT's loading conditions. However, excessive penetration may lead to upstream power flow beyond the feeder level. Further, slow EV chargers can generally be accommodated at the DT level, while fast chargers require dedicated feeder-level capacity calculation. It also identifies EV charging limits for varying DT capacities and highlights the importance of voltage regulation and reactive power management for a reliable grid operation. The findings offer insights to support RE and EV deployment to the network while simultaneously maintaining network stability.

Keywords: Solar PV, EV charging, Hosting capacity, load flow analysis, distribution network

1. Introduction:

Fast urbanization is increasing the electrical load at the end-user level. This further brings significant change in the distribution network through the large-scale deployment of distributed energy resources (DERs). In many regions, existing distribution infrastructure was originally designed for unidirectional power flow and relatively predictable load growth. However, the rapid growth of grid-connected loads, coupled with increasing penetration of renewable energy (RE) technologies and electric vehicles (EVs), is placing additional stress on conventional distribution systems. In transition towards low-carbon energy systems, solar PV and EV charging stations are playing a crucial role among the upcoming technologies [1] Solar PV systems provide clean electricity generation near consumption centers, while EVs offer a pathway to decarbonize the transportation sector [2]. However, the increasing integration of these technologies introduces new operational challenges for distribution networks [3,4]. High rooftop PV penetration may lead to reverse power flow, voltage rise, and increased feeder losses, particularly in low-voltage networks. Similarly, uncontrolled EV charging can significantly increase peak demand and create localized overloading of distribution transformers and feeders. The operational impacts on the EV charging units and PV rooftops have been mentioned by the authors in [5, 6]. Often, significant increases in transformer loading and peak demand are observed when charging is poorly managed in large-scale EV charging units [7]. Akinyemi et al. focused on the challenges posed by the high penetration of REs into the network. These mainly include reverse power flow into the grid and voltage regulations for low-voltage networks [8]. A few recent studies also examined the combined effects of integrating distributed energy sources and EV charging stations on the distribution system [9,10]. This highlighted the need for advanced planning tools to ensure reliable and stable network operation. In response to these challenges, distribution network operators gradually began relying on hosting capacity. These hosting capacities indicate the maximum number of RE generators or loads that can be integrated into the distribution network without compromising its stability. Hosting capacity assessments generally consider functional indices, such as transformer and line loading, voltage magnitudes, thermal limits, and other power-quality parameters. Numerous approaches have been proposed for assessing the hosting capacities. Traditional methods are mostly based on load flow analysis, while recent studies have integrated time-series simulations with probabilistic modeling [11]. Probabilistic methods are generally capable of capturing the uncertainty in RE generation. The Kerala State Electricity Board (KSEB) mainly depends on MI Power and PSS®E for load flow analysis at transmission levels (110 kV and above) [12]. For high-voltage transmission planning (110 kV and above), PSS/E is widely used because it is accepted by national and regional grid authorities [13]. For intermediate voltage levels (110 kV to 11 kV), MiPower is commonly used as a Windows-based platform for load flow and short-circuit analysis. However, these tools are mostly proprietary software with restrictive licenses, limiting user access and creating operational challenges. Moreover, these tools support planning for higher-voltage networks, while the distribution-level network is still managed manually and decentralized across different divisions. A dedicated open-source planning tool is still very sparse in this regard. This highlights a gap in the use of a data-driven planning framework at the network distribution level. Kerala has also set an ambitious sustainable goal to achieve net-zero carbon emissions by 2050. Under the State Action Plan on Climate Change (2023–2030), Kerala also aimed to generate 100% of its demand through renewable sources [14,15]. Despite an installed capacity of about 7,215 MW, the state depends mainly on electricity imports, with only 30-35% of its total generation coming from internal sources [16]. In FY 2022-23, total electricity consumption in Kerala was recorded at 25,383.77 MU, with the residential sector as the major contributor, driven by increased use of modern appliances. Moreover, the peak demand has also risen significantly from 3979 MW in 2015-16 to 5302MW in 2023-24. This increase was mainly driven by urban population growth, industrialization, and the adoption of electric mobility. Hence, integrating RE and EV charging units is more likely to affect load patterns, thereby necessitating a robust, reliable planning system. With this background, the current study explores the impact of RE integration and EV charging loads on the distribution-level network, focusing on a small area within Ernakulam Division. The study further evaluates the hosting capacities of solar PV rooftops and EV charging infrastructures within the selected feeders. Using an open-source platform, detailed simulations are conducted to assess network performance under different EV charging and PV penetration demand scenarios. The study aims to classify potential network constraints and develop strategies to improve the distribution system's operation.

2. Approach and Methodology

KSEB represents a distinctive institutional structure within India's power sector [16]. KSEB continues to operate as a combined utility responsible for generation, transmission, and distribution under a single structural framework. Though the integrated network provides operational continuity, planning across different voltage levels becomes very complex. Unbundling the generation, transmission, and distribution sectors may reduce complexity and shorten the time required to ensure reliable operation. However, the grid planning practices are relatively less advanced at the distribution level (below 11kV). This often relies on periodic manual data collection and on regulatory guidelines and static network representations. The load demand profile at the distribution level is changing rapidly due to the rapid growth of solar rooftops, the integration of distributed energy resources (DER), and EV charging infrastructure. Localized voltage fluctuations, peak demand increases, and bidirectional power flow often create challenges that are difficult to address with traditional methods. These advances highlight the need for more flexible planning tools that can model distributed generation, storage systems, and spatial network characteristics. To address these limitations, this study uses PyPSA (Python for Power System Analysis) as the primary planning simulation platform.

PyPSA is an open-source framework developed for power system modeling, optimization, and long-term energy planning. PyPSA is more flexible, extendable, and transparent than proprietary software tools, making it well-suited for grid planning.

A key strength of PyPSA lies in its ability to integrate geospatial data into power system modeling. All components and assets of a power system network, such as transmission lines, generators, loads, transformers, and storage units, are mapped to their geographic locations. This feature further helps to plan RE integration based on the site suitability. So, the model is basically a realistic representation of the actual network. First, the baseline scenario is developed based on the network's existing operational conditions. Next, a load flow analysis is performed to identify potential issues, such as line congestion, transformer overloading, and voltage deviations, under the baseline operational condition. Further, several operational scenarios have been developed, which include integration of different RE potential and EV capacity to the distributed network. RE mainly focused on solar photovoltaic generation at the feeder and distributed transformer level. The EV charging stations were considered as additional load connected to the distribution network. This scenario-based modelling helps to identify the potential impacts on the network, such as voltage fluctuations, reverse power flow to the grid, DT and feeder loadings, with increase in the level of solar generation, and EV load.

The model was simulated through load flow constraints under different scenarios. The optimization framework in PyPSA works in terms of modelling features considering system constraints.

Nodal power balance, transmission constraints, generator operational limits, and voltage regulation are mainly the constraints. Nodal power balance ensures that electrical supply matches demand at every bus in the network. Generator operational limits impose that generation remains within prescribed minimum and maximum capacities. Transmission constraints confirm that power flows remain within the thermal and stability limits of network lines, while voltage regulation maintains voltage levels across buses within acceptable ranges to ensure reliable system operation.

The framework's features include solver integration, multi-paradigm optimization, and integrated planning functionality. The interface with external solvers helps to compute optimal solutions efficiently. It supports several optimization paradigms, including Linear Programming (LP), Mixed-Integer Linear Programming (MILP), Nonlinear Programming (NLP), and Quadratic Programming (QP), depending on the problem's complexity. Furthermore, it enables the co-optimization of generation, storage, and transmission infrastructure, simultaneously accounting for the spatial characteristics of the electrical grid.

2.1 Load Flow Constraints Under Different Scenarios

Under the baseline scenario, the load flow analysis considers line and generator limits while matching load to supply. Equation (1), shows the power balance equation under the baseline scenario

Base Scenario (Conventional Load Flow)

$$\sum_{i\in G_n} g_{i,t} - d_{n,t} = \sum_{l\in \mathrm{inc}(n)} f_{l,t} \tag{1}$$

Here, $g_{i,t}$ is the generation output and $d_{n,t}$ is the demand during time t, and $f_{l,t}$ is the power flow in the line. The constraints are mentioned below in equations (2) and (3) as line limits and generator limits.

$$F_l^{\min} \le f_{l,t} \le F_l^{\max} \tag{2}$$

Where, $F_{l\min}$ and $F_{l\max}$ are the minimum and maximum limits of the lines and feeders.

$$g_i^{\min} \le g_{i,t} \le g_i^{\max} \tag{3}$$

Here, $gi^{\min}$ and $gi^{\max}$ are the minimum and maximum limits of the generator

Solar Generation Scenario

In the solar generation scenario, the power balance accounts for the addition of solar generation, as shown in equation (4). The generation and curtailment limits for the solar are given below in equations (5) and (6)

$$\sum_{i\in G_n} g_{i,t} + g_{n,t}^{\mathrm{solar}} - d_{n,t} = \sum_{l\in \mathrm{inc}(n)} f_{l,t} \tag{4}$$

Here, $g_{n,t}$ solar is the generation of solar during time t,

$$0 \le g_{n,t}^{\mathrm{solar}} \le g_{n,t}^{\mathrm{solar,max}} \tag{5}$$

where, $g_{n,t}$ solar, max is the maximum installed capacity for solar that can be generated

$$g_{n,t}^{\mathrm{solar}} \le \mathrm{availability}_{n,t} \tag{6}$$

EV Load Scenario

In the EV load scenario, an additional EV load has been considered in the power balance equation as shown below in equation (7). Equation (8) represents the maximum limit of EV injection

$$\sum_{i\in G_n} g_{i,t} - (d_{n,t} + d_{n,t}^{\mathrm{EV}}) = \sum_{l\in \mathrm{inc}(n)} f_{l,t} \tag{7}$$

$$0 \le d_{n,t}^{\mathrm{EV}} \le d_{n,t}^{\mathrm{EV,max}} \tag{8}$$

Where, $d_{n,t}{}^{\mathrm{EV,max}}$ is the maximum capacity that can be installed to the network

Besides, the power balance equation, along with the constraints, was used to simulate the power flow in the lines under the constraints shown in equations (9) and (10) for all three scenarios.

$$f_{l,t} = B_l(\theta_{n,t} - \theta_{m,t}) \tag{9}$$

$$f_{l,t} = B_l(\theta_{n,t} - \theta_{m,t}), -F_l^{\max} \leq f_{l,t} \leq F_l^{\max} \tag{10}$$

Here, $f_{l,t}$ is the power flow in the line l, during time t. B_l is the line susceptance, and $F_{l,}^{\ max}$ and $F_{l,}^{min}$ denote the maximum and minimum power flow permissible in that distribution line or feeder.

For the case study analysis, the Ernakulam Electrical Division in the state of Kerala was selected. Palarivattom, Central, Edapally, Girinagar, Kaloor, Thevara, Vaduthala, Vennala, College, and Cheranellur are the sections within the Ernakulam division. The Cheranellure section was chosen for detailed network analysis across baselines and other scenarios. The Cheranallure section includes two feeders, Pachalam and Periyar. The Pachalam feeder entails 21 distribution transformers, while the Periyar feeder has 26.

The inputs for developing the twin model of the chosen network and for simulating it further are described in the next section.

3. Input Data:

3.1 Network Components

An overview of all the data required and collected for this study is presented in Table 1 below. The data, received from KSEB, mainly includes the single-line diagram (SLD) of the Ernakulam division network and a shapefile detailing the network components and their geographical locations.

Table 1: Overview of data received from KSEB for modeling

System	Data points	Department
Feeder data	Hourly load profile for Pachalam and Periyar feeders for FY 2023-24	IT department
Single Line Diagram (SLD)	SLD of the Cheranellure section received that helped in developing the network topology	IT department/Ernakulam division
Shape Files for the entire Ernakulam Division	Spatial and attribute information about different power grid components such as transmission network, substations, distribution lines, distribution transformer (DTs) and loads were extracted from the provided shape files.	Planning team
Distribution transformers	DTs connected to both feeders were received, that has information related to DT capacity and solar installed capacity at these DTs Resistance, reactance, short circuit voltage, No Load iron losses and No-Load Current were assumed	IT department/Ernakulam division
Line data	KSEB provided line data that include specifications such as size, conductor type, minimum breaking load, insulation details resistance, max current and tensile strength. Nominal power and operation cost were assumed	Planning team

Solar Data	Installed capacity at DT level was provided. Hourly generation profile was also taken from Renewable. ninja	IT department/RE data center
EV charging Data	The daily charging load of the Vytilla charging station was used for EV-related simulation	Planning team

A representative figure of the Ernakulam network's shapefile, provided by KSEB, is shown in Figure 1.

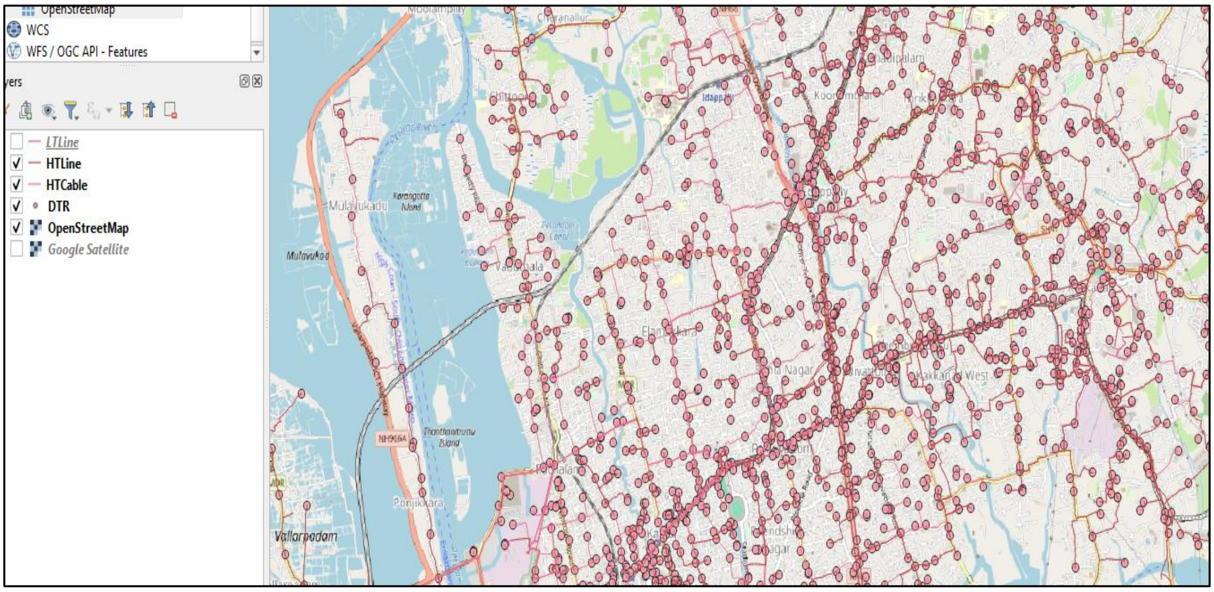

Figure 1: The shape file for Ernakulam Division showing all HT lines, HT cable and DTRs

The data received for the transformers includes both the capacity of each distribution transformer (DT) and the solar capacity installed on them.

3.2. Line's data at the distribution level

Line data is an important piece of information that ensures the connectivity of all the network components of power distribution systems. The length of the overhead lines and cables are extracted from .shp files. Other parameters, such as conductor type, conductor current, and conductor resistance/km and reactance/km, were provided by KSEB. The line rating in MVA have been further calculated and considered for this study.

3.3. Hourly load profile data

Feeder: KSEB provided hourly load profile data at the feeder level for the Periyar and Pachalam of FY 2023-24. This data comprises hourly measurements of voltage, current, power, and power factor.

Solar: The hourly generation profile for each geographically specific DT was calculated. This generation profile was generated using Renewables. ninja[1]. This data considers the solar potential of each location for both winter and summer representative days selected for the study.

Based on all the inputs, the network model was developed and further simulated for detailed analysis, as explained in the following section.

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[1] https://www.renewables.ninja/

4. Results

The results of the study have been presented under the scenario classification.

4.1 Baseline Model Establishment

The input data were formatted in accordance with PyPSA (Python for Power System Analysis), and the baseline network model was developed. The network was structured from the Edappally 11 kV substation to the feeder feeding points and, further, to the distribution transformers (DTs), as illustrated in Figures 5 and 6 for the Pachalam and Periyar feeders, respectively.

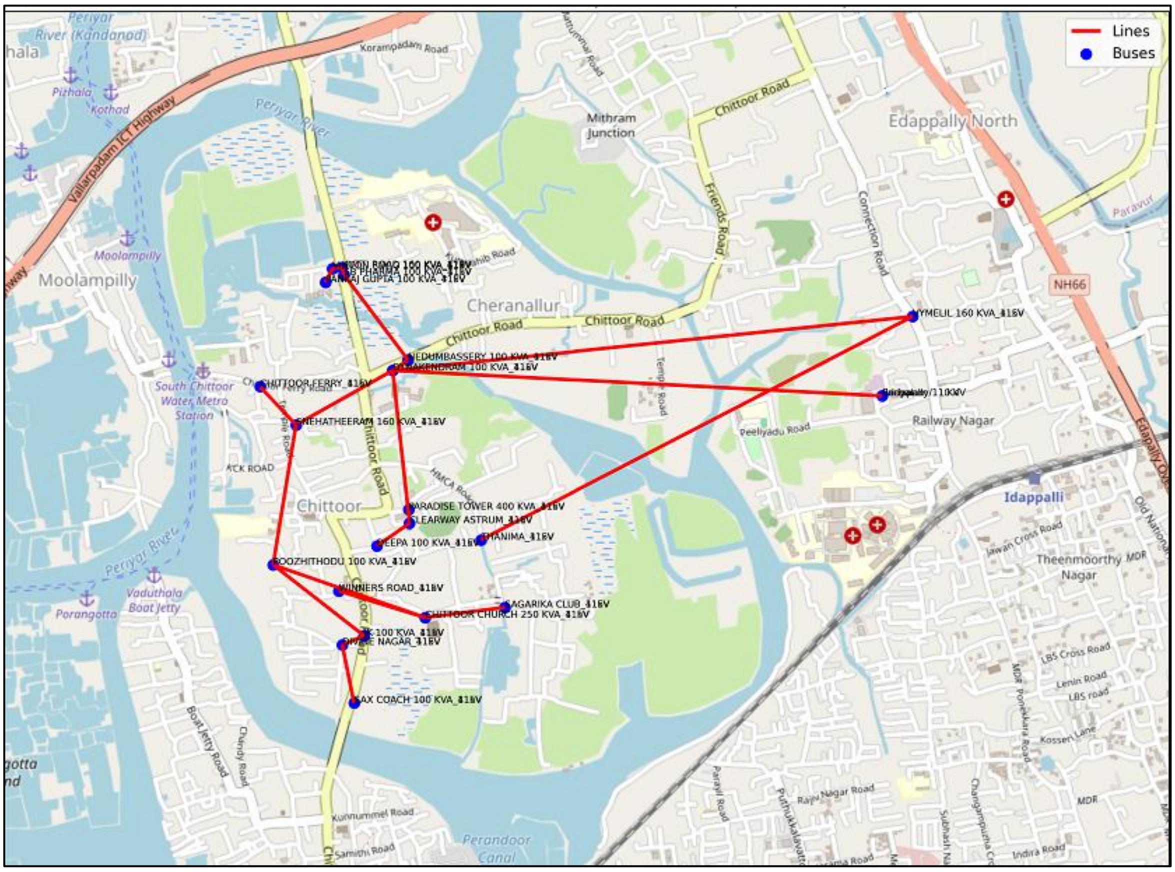

Figure 5: Network of Pachalam Feeder

To capture seasonal variations in load, the baseline model was simulated for 8760 hours. The DT load profiles revealed two major peak demand periods: one during the daytime and another during the evening hours.

Figure 6: Network of Periyar Feeder

During both summer and winter, loads peaked around 4 PM and 11 PM in the Pachalam feeder. In the Periyar feeder, peak hours varied slightly by season, with peaks around 4 PM and 10 PM in summer and 3 PM and 11 PM in winter. Despite these peaks, DT and line loadings remained within the defined operational limits under the baseline scenario.

4.2 Scenario Case Studies

To accommodate additional Distributed Renewable Energy (DRE) sources and Electric Vehicle (EV) charging infrastructure, scenario simulations were conducted for the Cheranellure section. The objective is to determine the maximum additional capacity that could be integrated without violating grid operational constraints.

For solar PV integration, the analysis was carried out at the DT level.

Due to typical residential installations, slow EV chargers were evaluated at the DT level, while the fast EV chargers, which require dedicated transformers, were analyzed at the feeder level.

Each scenario was evaluated based on four key technical parameters:

- Distribution transformer loading
- Line loading
- Bus voltage
- Reactive power flow

These parameters were evaluated against operational limits recommended by the Central Electricity Authority (CEA). The network's hosting capacity was found to depend on several factors, such as distance from the substation, feeder configuration, existing connected load, and load type (residential, commercial, or solar-fed).

4.2.1 Case 1: Renewable Energy Integration

Solar PV integration was analyzed by incrementally adding solar capacity at the DT level. Simulations were performed by adding solar capacities of 20 kW, 25 kW, 30 kW, 35 kW, and 40 kW to the DTs of the network. At 40 kW of solar capacity, several DTs exceeded the 90% loading threshold, and one transformer exceeded 100% loading between 1 PM and 2 PM. To determine the maximum permitted capacity, the simulations were repeated with incremental reductions (39 kW, 38 kW, etc.). A representative case study for the Chittoor Church DT (250 kVA) showed that up to 35 kW of additional solar capacity can be integrated without disturbing operational limits. The DT loading remained below 90%, with minimum line loading, and bus voltages within acceptable limits (0.952–0.962 p.u.). However, higher solar penetration led to transformer overload, highlighting the need for careful hosting capacity assessment.

Impact on DT Loading

Figure 7 illustrates the change in DT loading before and after solar integration. Solar generation significantly reduced transformer loading during midday. The largest reduction occurred around 11:00 AM, when solar output was highest.

Impact on Voltage

Variation in load on the distribution transformer with bus voltage over a 24-hour period is portrayed in Figure 8. An inverse relationship between load and voltage is observed. Voltage reduction with an increment in load during evening peak hours has been particularly noted.

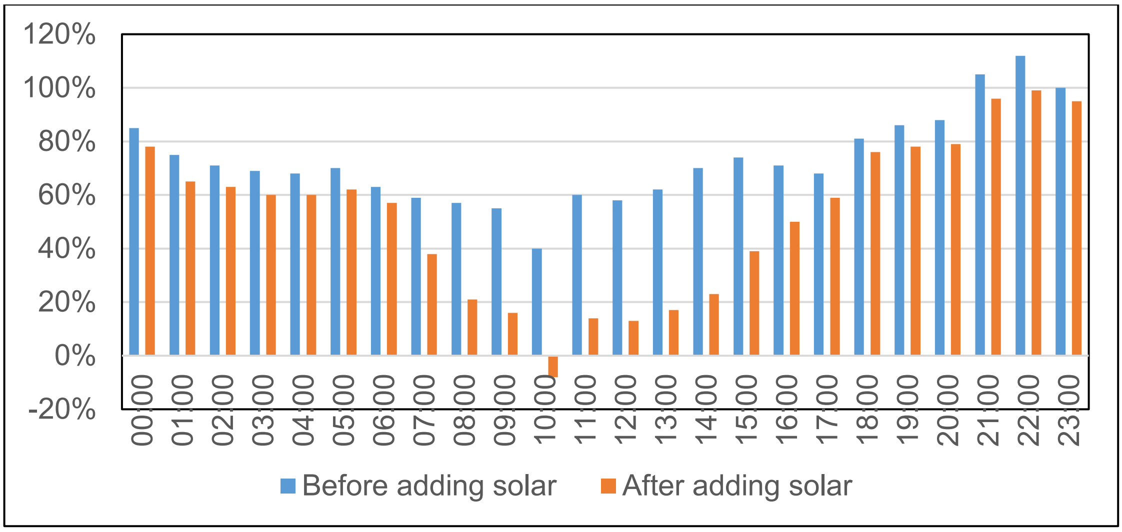

Figure 7: Impact on DT loading when 38 kW solar is installed at Chittoor Church DT.

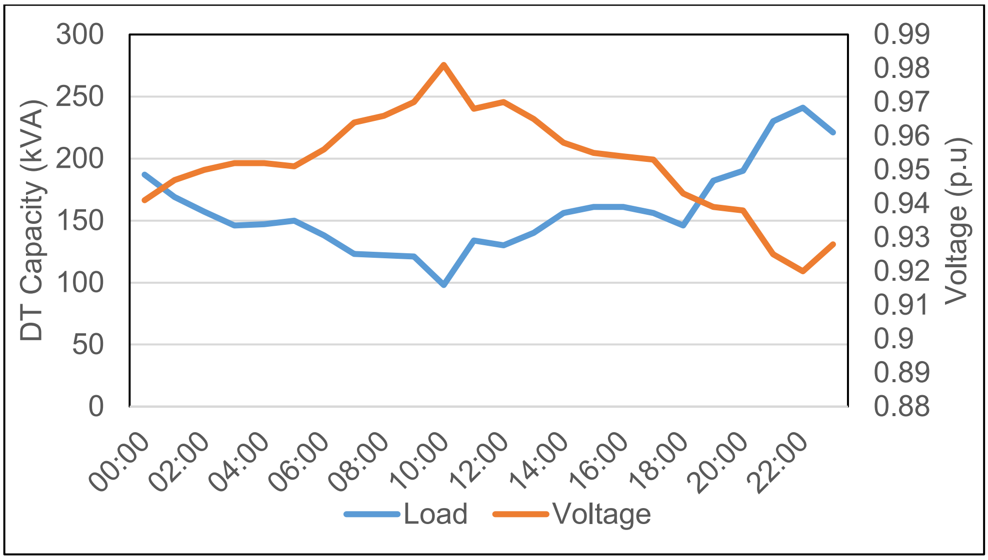

Figure 8: Voltage profile with the load at a representative DT for 24 hours

Tables I and II, in the appendix below, show the maximum solar hosting capacity for each DT of the Pachalam and Periyar feeders under the Cheranellure Section, respectively. Transformer capacities, existing solar installations, and additional hosting capacity for the Pachalam feeder are shown in Table I. The installations range from 3 to over 62 kW, with transformer capacities of 100-250 kVA; most DTs can accommodate an additional 30–35 kW, depending on rating and seasonal load. Table II shows similar results for the Periyar feeder, with installed solar ranging from 3.5 to about 96.4 kW and transformer capacities from 100 to 315 kVA, with most DTs able to integrate an additional 20–40 kW. Overall, DTs across both feeders can host approximately 20-40 kW of additional solar capacity, depending on the existing load and transformer rating. This analysis was further extended to assess hosting capacity for all DTs in the Cheranellure section using multiple scenario matrices.

4.2.2 Case 2: Integration of EV Charging Infrastructure

EV charging integration was analysed considering two types of chargers:

- Slow Chargers (3.3 kW – 22 kW), are typically used for residential and public slow-charging stations.

- Fast Chargers (60 kW – 240 kW and above), are mainly used in highways, commercial hubs, and public charging stations.

Fast chargers were analysed at the feeder level, since they require dedicated distribution transformers, while slow chargers were analysed at the DT level due to their residential deployment. Peak loading analysis showed that the Pachalam feeder reached 139% loading, while the Periyar feeder reached 59%. Therefore, EV charging scenarios were primarily simulated for the Periyar feeder.

- **Feeder-Level Analysis**

Fast chargers were connected with dedicated transformers and analysed at the feeder level. Results showed that feeder loading increased from 59.28% to approximately 61-68%, depending on charger capacity.

The results indicate that:

160 kVA transformers can support up to 60 kW chargers
250 kVA transformers can support up to 120 kW chargers
315 kVA transformers can support up to 180 kW chargers
For 240 kW fast chargers, transformers larger than 315 kVA are required.

Voltage deviations remained within 1.3%–3.5%, and reactive power flow increased marginally, indicating that the network can accommodate EV charging loads within the analyzed range.

- **DT-Level Analysis**

Slow chargers were analyzed for selected DTs and were found to increase transformer loading from about 32.5% to 33–48%, depending on charger capacity and DT rating. The voltage drops and reactive power changes remained minimal within the acceptable limits. Overall, slow chargers can generally be accommodated at the DT level without immediate upgrades, whereas fast chargers require careful feeder-level planning and transformer capacity assessment. To estimate EV hosting capacity, DT ratings in the Cheranellure section (ranging from 100 to 315 kVA) were analyzed under peak loading conditions. Feeder-level results showed a maximum loading of 139% for the Pachalam feeder and 59% for the Periyar feeder on April 30th. Due to the already high loading on the Pachalam feeder, high-capacity fast chargers were integrated into the Periyar feeder for analysis, while slow chargers were evaluated at selected DTs. For DT-level assessment, three representative DTs with residential and solar loads from the Pachalam feeder were considered to examine the impact on DT and feeder loading.

Periyar Feeder: Simulations were conducted at both feeder and DT levels, with high-capacity fast chargers connected through dedicated transformers at the feeder level and slow chargers added to three representative DTs. The initial feeder loading of 59.28% increased to 61.5–68.4% after integrating fast chargers, depending on transformer capacity. The analysis indicates that 160 kVA DTs can support up to 60 kW chargers, 250 kVA up to 120 kW, and 315 kVA up to 180 kW, while 240 kW chargers require transformers above 315 kVA; however, these values are indicative and depend on existing loads. At the DT level, slow chargers increased loading from 32.5% to 33–48%, depending on transformer rating and charger capacity. Bus voltage decreased slightly with increasing charger capacity (e.g., from 0.982 to 0.977 p.u. for a 100 kVA transformer), with overall variations of 1.3–3.5%. Reactive power flow also increased modestly (e.g., from 0.07343 to 0.076021 MVAr), with changes of about 1–2.5%, indicating limited impact on network performance.

Pachalam Feeder: Although the Pachalam feeder was already heavily loaded (~139% at peak hour, 10 PM), simulations were conducted to assess the integration of slow chargers at selected DTs (Table 21). The results show that DT loading increases significantly with charger addition, reaching 118% for DYNAKENDRAM (100 kVA), 114% for CHITTOOR CHURCH (250 kVA), and 115% for PARADISE

TOWER (400 kVA). Bus voltage decreases slightly to 0.96 p.u., 0.948 p.u., and 0.956 p.u., respectively, with a moderate variation of 4–5.2%. Reactive power flow increases marginally, ranging from 0.00321 to 0.02466 MVAr, with a change of about 1–3%. Overall, while a 3.3 kW EV charger significantly impacts DT loading, especially for lower-capacity transformers, the effects on feeder loading, voltage, and reactive power are moderate, highlighting the importance of considering DT capacity in EV integration planning. Overall, the results show that while integrating high-capacity EV chargers increases feeder and transformer loading, the impacts on voltage and reactive power flow remain limited. Transformers with higher capacities are better able to accommodate EV charging loads while maintaining stable network operation. Tables III and IV in the appendix below show the maximum EV charging station capacity for each DT of the Pachalam and Periyar feeders, respectively, under the Cheranellure Section.

5. Conclusion

The baseline simulations indicate that the Cheranellure distribution network experiences high loading during peak hours (around 4 PM and 11 PM), leading to potential transformer stress and overloading, while voltage variations at both 11 kV and 415 V levels remain within acceptable limits. The hosting capacity analysis shows that several DTs can accommodate additional solar PV without violating constraints; for instance, the Chittoor Church 250 kVA transformer can integrate additional capacity while maintaining acceptable voltage and loading, provided proper power flow and reactive power management are implemented. The integration of EV charging increases feeder and DT loading, highlighting the need for careful planning of charging locations. While slow chargers can generally be accommodated at the DT level, high-capacity fast chargers require dedicated transformers and feeder-level assessment to avoid congestion and voltage drops. Overall, the study shows that the existing distribution network in the Ernakulam Division can accommodate additional renewable energy and EV charging infrastructure with appropriate planning and operational strategies. Key measures include upgrading transformer and feeder capacities, implementing smart grid monitoring, optimizing solar PV placement, and adopting demand-side strategies such as off-peak EV charging and load balancing. Geospatial-based power system analysis can enable more accurate, data-driven planning of future distribution networks; coupled with strengthening infrastructure and adopting advanced grid management strategies, this will be essential for ensuring a resilient, sustainable power system aligned with Kerala’s long-term clean energy goals.

6. Appendix

Table I: Available hosting capacity of the DTs of Pachalam Feeder for solar

Name	Bus	Existing Solar Installed (kW)	Existing DT capacity (kVA)	Maximum Additional Capacity (kW)
Solar_Pachalam_DT1	CHITTOOR CHURCH 250 KVA_415V	29	250	35
Solar_Pachalam_DT2	CHITTOOR FERRY_415V	62.175	250	35
Solar_Pachalam_DT4	DEEPA 100 KVA_415V	43.7	160	32
Solar_Pachalam_DT5	DIVINE NAGAR_415V	57.04	250	35

Solar_Pachalam_DT6	DYNAKENDRAM 100 KVA_415V	3	100	30
Solar_Pachalam_DT8	KUTTI ROAD 160 KVA_415V	9.8	160	30
Solar_Pachalam_DT12	POOZHITHODU 100 KVA_415V	15	100	32
Solar_Pachalam_DT13	SAGARIKA CLUB_415V	10	100	30
Solar_Pachalam_DT15	SB PHARMA 100 KVA_415V	6	100	30
Solar_Pachalam_DT16	SNEHATHEERAM 160 KVA_415V	54	160	30
Solar_Pachalam_DT17	THANIMA_415V	5	250	25
Solar_Pachalam_DT19	VYMELIL 160 KVA_415V	11	160	30
Solar_Pachalam_DT20	WINNERS ROAD_415V	10	100	25

Table II: Available hosting capacity of the DTs of Periyar Feeder for solar integration

Name	**Bus**	**Solar Installed (kW)**	**Existing DT capacity (kVA)**	**Maximum Additional Capacity (kW)**
Solar_Periyar_DT1	ACHUNNIKAVALA_415V	43.34	315	38
Solar_Periyar_DT2	AL- FAROOQ IA_415V	36	100	32
Solar_Periyar_DT4	BAGAVATHI TEMPLE 250 KVA_415V	37.515	250	38
Solar_Periyar_DT5	BANK ROAD 160 KVA_415V	34.3	160	32
Solar_Periyar_DT6	CHERANALLOOR FERRY_415V	96.375	250	30
Solar_Periyar_DT9	FRIENDS ROAD_415V	5	100	32
Solar_Periyar_DT10	HIGHWAY MOSQUE 250 KVA_415V	15	250	35
Solar_Periyar_DT11	HIGHWAY NO 1 100 KVA_415V	28.3	160	32
Solar_Periyar_DT12	HIGHWAY NO 2 250 KVA_415V	39	250	38
Solar_Periyar_DT14	KACHERIPADI 315 KVA_415V	40.8	315	35
Solar_Periyar_DT15	KARIMPADAM_415V	9.9	160	35

Solar_Periyar_DT17	METRO PARADISE 100 KVA_415V	8	100	35
Solar_Periyar_DT18	MUNDIYATH 250 KVA_415V	68.47	250	35
Solar_Periyar_DT20	ROTARY COLONY 100 KVA_415V	18.39	100	35
Solar_Periyar_DT21	ST ANTONYS_415V	5	160	25
Solar_Periyar_DT22	ST JAMES 250 KVA_415V	61	250	32
Solar_Periyar_DT23	ST MARYS CONVENT 100 KVA_415V	3.5	100	20
Solar_Periyar_DT24	VALAM 160 KVA_415V	3	160	20
Solar_Periyar_DT25	YASHORAM 315 KVA_415V	91	315	32

Table III: Available hosting capacity for different DT Capacities at Feeder level for integration of fast EV Charger

Installed Capacity of Transformer at Feeder Point	**EV Charger Capacity (kW)**	**Feeder Loading (%)**	**DT Loading (%)**	**Voltage at Bus**	**Percentage Change in Voltage at Bus (%)**	**Reactive Power flow @-Periyar feeder (MVAr)**	**Percentage change in Reactive Power flow change (%)**
100 kVA	60	61.56	60	0.982	1.8	0.07343	1
	120	63.84	120	0.977	2.3	0.076021	2
160 kVA	60	61.56	37.5	0.982	1.8	0.07213	1
	120	63.84	75	0.96	1.5	0.075821	1
	180	66.13	112.5	0.965	3.5	0.08352	2
250 kVA	60	61.56	24	0.0985	1.5	0.07066	1
	120	63.84	48	0.982	1.8	0.07435	1
	180	66.13	72	0.984	1.3	0.08081	2
	240	68.41	96	0.974	2.6	0.08964	2
315kVA	60	61.56	19	0.992	1.4	0.06981	1
	120	63.84	38	0.983	1.7	0.0737	1
	180	66.13	57	0.980	2	0.07859	1
	240	68.41	76	0.977	2.3	0.085	2
	300	70.69	95.4	0.974	2.6	0.0969	2.5

Table IV: The Parameters with integration of Slow EV Charger at DT level at Periyar Feeder

Name of the DTs	Installed Capacities of the DTs	EV Charger Capacity (kW)	Feeder Loading (%)	DT Loading (%)	Voltage at Bus (p.u)	Percentage Change in Voltage (%)	Reactive Power flow (MVAr)	Percentage change in Reactive Power flow (%)
ACHUNNIKAVALA	315kVA	3.3	59.41	33.3	0.976	2.4	0.00321	0.6
		7.4	59.56	35	0.975	2.4	0.0033	1
		11	59.7	36	0.975	2.4	0.0034	1.5
		22	60.12	39	0.975	2.4	0.00419	2
AL- FAROOQIA	100 kVA	3.3	59.41	36	0.968	3.2	0.0037	0.6
		7.4	59.56	40	0.965	3.5	0.0039	1
		11	59.7	44	0.965	3.5	0.004	1
		22	60.12	55	0.965	3.5	0.0041	1.5
CHERANALLOOR FERRY	250 kVA	3.3	59.41	34	0.968	3.2	0.0038	0.5
		7.4	59.56	36	0.956	4.4	0.0041	0.5
		11	59.7	37.5	0.955	4.5	0.0046	1
		22	60.12	46	0.957	4.3	0.0048	1

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