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Idam Infrastructure Advisory Private Limited

EXECUTIVE SUMMARY

Report on

Designing Distribution Network Optimization Strategies in View of the Changing Landscape for an Electric Utility in Rajasthan

Submitted to

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

Prepared by

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1. Background

The evolving landscape of a distribution network with higher penetration of Distributed Energy Resources (DERs) necessitates upgradation in the distribution network along with its associated investment. In addition to the investment, the practices of distribution planning and the planning horizon need to be critically reviewed for necessary revision. In the Indian context, distribution utilities initiate such exercises for coping with the increasing penetration of DERs in their respective network and for effective management of the distribution network.

Idam Infrastructure Advisory Pvt. Ltd. (Idam Infra) in association with Shakti Sustainable Energy Foundation carried out a detailed study on designing distribution network optimization strategies with the support of Jaipur Vidyut Vitaran Nigam Limited (JVVNL).

For the pilot study on assessing the impact of DER on the distribution network, 33/11 kilovolt (kV) substation (SS) within the Vaishali Nagar subdivision area of JVVNL and the downstream network was considered. The identified area for the study also includes the significant installation of solar rooftop systems.

In this study, four specific aspects have been looked at from the point of view of increasing DER penetration and preparations required by distribution utilities.

- Assessment of impact of distributed technologies on the distributed network loading as part of the pilot study.
- Assessment of commercial impact of distributed technologies.
- Assessment of capital expenditure (capex) requirement for grid modernization.
- Development of new planning indicators and revisions required in planning practices considering the changing landscape of the distribution grid.

The results of the same are presented in the following sections.

2. Pilot Study — Impact Assessment of Distributed Technology

The pilot study was carried out at 33/11 kV Vaishali Nagar SS and its downstream network in the JVVNL area. Load simulations with DERs were carried out and projections of various scenarios was performed for 10 years, i.e., till 2030.

The detailed impact analysis and simulation on loading of 33/11 kV Vaishali Nagar SS owing to DER penetration has been carried out.

Based on the simulation, load curves considering the addition of different DERs in the distribution network in FY 2020, FY 2025 and FY 2030 are as follows.

Load Curve in FY 2020

Key assumption taken in FY 2020 simulation:

- No Electric Vehicle (EV) load is considered for FY 2020.
- No storage is considered for FY 2020.

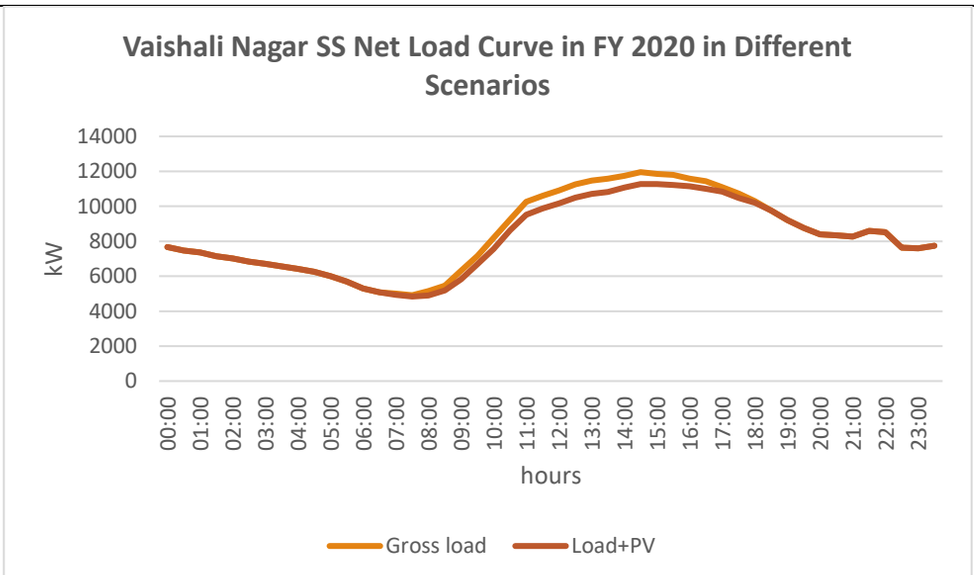


Figure 1: Vaishali Nagar SS Net Load Curve in FY 2020 in Different Scenarios

Load Curve in FY 2025

Key assumption taken in FY 2025 simulation:

- Year on Year (Y-o-Y) 7% load escalation rate is taken.
- Y-o-Y 5% Solar Photo Voltaic (SPV) capacity addition is considered. Here, PV penetration is considered as the percentage of SS capacity.
- For PV penetration, two cases are considered:
  (1) More than 30% of SS capacity is allowed.
  (2) More than 30% of SS capacity is not allowed.

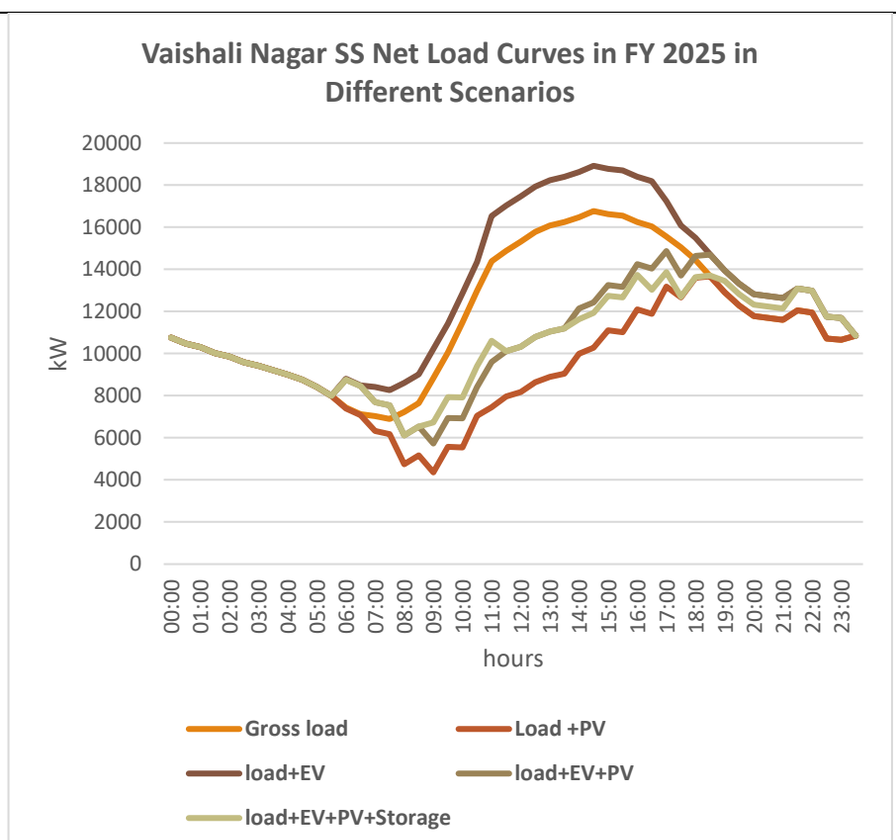
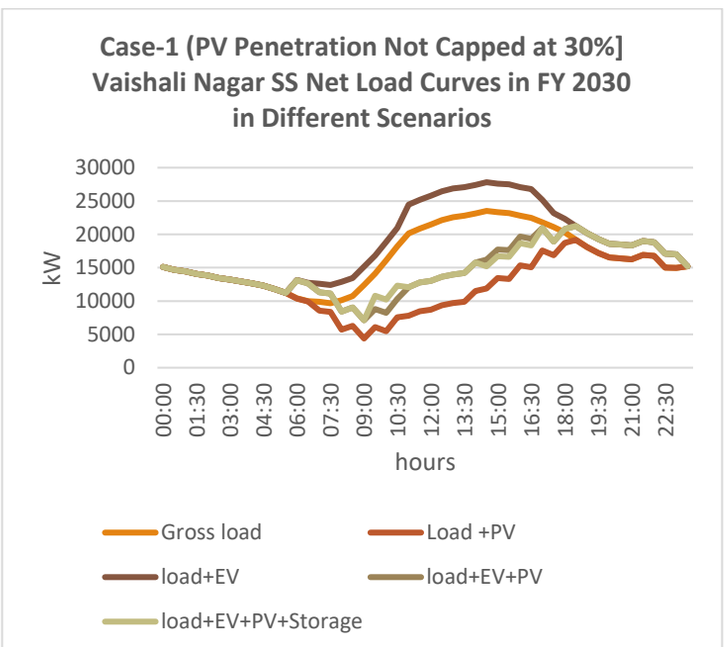


Figure 2: Vaishali Nagar SS Net Load Curve in FY 2025 in Different Scenarios

Load Curve in FY 2030

Key assumption taken in FY 2030 simulation:

- 1. Y-o-Y 7 % load escalation rate is taken.
- Y-o-Y 5% PV capacity addition is considered. Here, this PV penetration is considered as the percentage of SS capacity.
- For PV penetration, two cases are considered: (1) More than 30% of SS capacity is allowed. (2) More than 30% of SS capacity is not allowed.



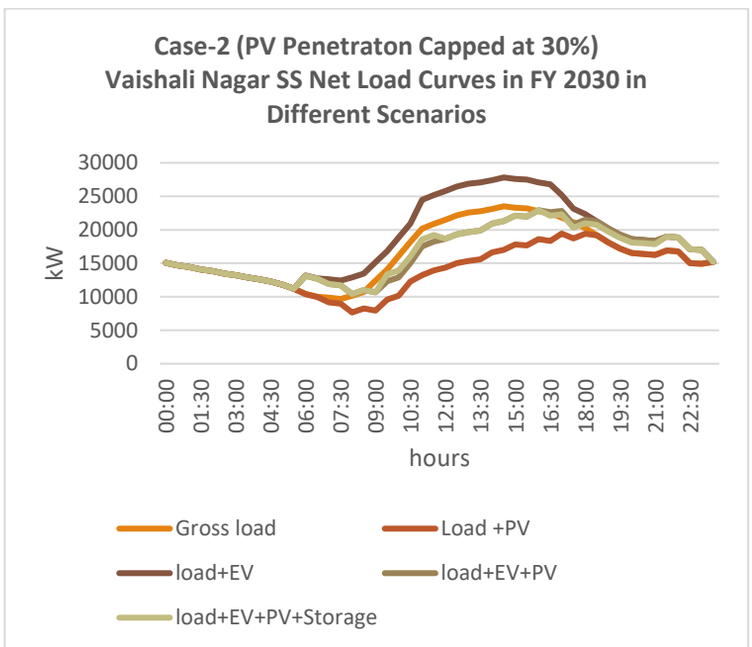


Figure 3: Vaishali Nagar SS Net Load Curve in FY 2030 in Different Scenarios (Case 1 & Case 2)

3. Key Inference from Pilot Study

FY 2020 Scenario	FY 2025 Scenario	FY 2030 Scenario
• For FY 2020, 1,000 kW PV installed capacity is considered at the SS level (based on the available data). • In FY 2020, EV load penetration was significant. So, for FY 2020, EV load is considered as zero. • In FY 2020, net loading at Vaishali Nagar SS was nearly 50% of the installed capacity of 24 MVA.	• As per assumptions, by FY 2025, the PV penetration would reach 30% of SS capacity (24 MVA). • In FY 2025, for both PV penetration cases (case 1 and case 2), the net load curves for all scenarios would be the same. • In load + PV and load + PV + EV scenarios, the net load is lesser than the gross load due to significant PV generation. • If by FY 2025, PV installed capacity would reach around 9.5 Mega Watt (MW) in the Vaishali Nagar SS area, then the net load would be reduced by 26% of gross peak load in (load + PV) scenario and 39% in (load + PV + EV) scenario.	• In case 1, when PV penetration is not capped at 30% of SS capacity, the net peak load would be reduced by 49% and 31% of gross peak load in (load + PV) and (load + PV + EV) scenario respectively. • In case 2, when PV penetration is capped at 30% of SS capacity, the net peak load would be reduced by 28% and 9% in (load + PV) and (load + PV + EV) scenario respectively.

4. Assessment of Commercial Impact on JVVNL Due to DERs

A detailed assessment carried out over the next 10 years shows that an installation of around 2,000 MW of distributed solar by 2030 has only got a limited impact on the JVVNL commercials. The assessment was carried out in terms of the aggregate impact of:

- Savings in power purchase owing to reduced sales due to DERs.
- Savings in terms of deferral of capex as the net loading would remain within the limit for more years, as part of the load on the network will be taken care by the DERs.
- Loss on account of reduction of tariff revenue from consumers shifting to solar prosumers.

Even though there will be loss during the initial years, JVVNL would yield net benefit with capex deferral benefit in the future. In addition, the solar generation and corresponding consumption by consumers of JVVNL can be counted towards JVVNL's compliance with the yearly Renewable Purchase Obligation (RPO) set by the state regulator.

5. Assessment of Capital Expenditure

As part of grid modernization, the following capex schemes have been proposed with the respective capital outlay for deployment at both JVVNL and Vaishali Nagar sub-division levels.

- To overcome the challenges of DER integration, it is important to calculate how much Distributed Generation (DG) can be integrated into a given distribution network without violating the distribution network's operational criteria (thermal, voltage/power quality, protection, and reliability). This is called **Hosting Capacity (HC)** and is defined as the capacity of DERs that can be incorporated into a given distribution network while keeping its performance within an acceptable range and without making any modifications to the existing power system infrastructure.

- A **Distributed Energy Resource Management System (DERMS)** is a software-based solution to monitor, forecast and control grid-connected and Behind the Meter (BTM) DERs across customer, grid, or market applications in real-time. These assets may be utility, third-party, or customer-owned and directly or indirectly controlled by the utility.

6. New/Revised Distribution Planning Indicators

Existing distribution networks are not designed to accommodate two-way power flow. Hence, increasing DER penetration is causing profound changes in the planning, operations and maintenance of distribution networks. While the peak/connected load and voltage regulation limit would continue to be the key factors considered for distribution planning, the evolving significance of DERs shall bring in additional related factors. Further, **the integrated distribution planning approach** calls for consideration of various new factors for distribution grid expansion.

Table 1 lists the key existing and new/additional planning indicators.

Table 1: Key Existing and New/Additional Planning Indicators

Existing Planning Indicators	New/Additional Planning Indicators
• Voltage regulation limits • Growth in peak load • Application for supply/connection involving grid expansion • Supply to areas with no provision of supply • Grid safety and minimum interruption	• Growth scenarios of distributed solar generation • Growth scenarios of electric vehicle • Incremental grid safety/protection requirements from DER penetration perspective

The following strategies have been proposed to be adopted by JVVNL for its distribution network optimization:

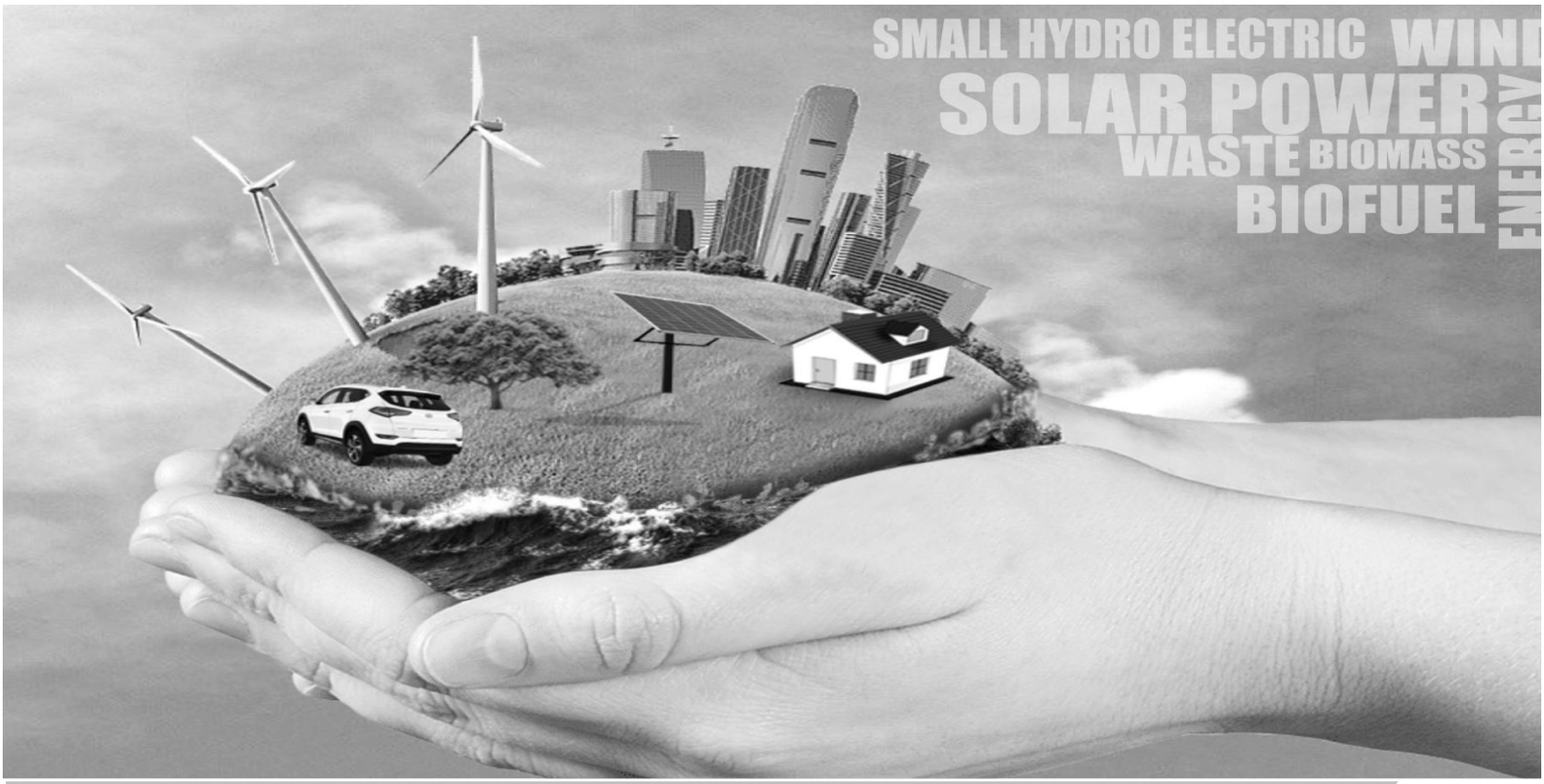
- Network expansion plan and investments to be kept at optimum level.
- Holistic approach towards network planning to be adopted considering the revised planning indicators in the study.
- Network expansion plans to be decided only after considering the following:
  - Expected solar penetration in the grid (detailed Hosting Capacity Analysis [HCA] to be carried out in 11 kV distribution network across the DISCOM).
  - Expected additional load due to EVs. Formulate/Propose rules (tariff or otherwise) such that EV charging has minimal effect on the peak load (encourage charging during non-peak period).
  - Explore the option of local level (at 33 kV GSS) Battery Energy Storage System (BESS) solutions for maximum utilisation of solar generation.
- Integrate distribution expansion plans with the transmission plans to be prepared. The same must be in sync with the overall grid system requirement.
- JVVNL to prepare short- and long-term planning horizons for distribution network planning as against today's distribution planning on a 'need basis' approach.
- Deploy latest technology schemes such as DERMS, whereby generation from DERs can be actively managed to keep the net load of the system at a minimum level.

7. Key Recommendations and Way Forward

JVVNL is a proactive distribution utility with some of the foundational infrastructure for adopting DERs already in place. It has a robust distribution Supervisory Control and Data Acquisition (SCADA) system in place and is undertaking Distribution Transformer (DT) metering across the distribution utility. Some additional schemes and planning practices are recommended in the study, the implementation of which would gear up JVVNL in the necessary grid modernisation required in this context.

Distribution network optimization strategies will be necessary for all the utilities considering the targets and plans of the government for Renewable Energy (RE), EVs and storage systems in electricity networks in coming years. Accordingly, recommendations for utilities and specifically JVVNL based on the pilot study results are summarized below.

- Utilities shall select the right tool/software for HCA and DERMs by integrating it with the already existing SCADA system
- Utilities shall carry out the pilot study for distribution network optimisation at a few 33 kV SS levels
- Utilities shall follow a step-by-step process of distributed network optimisation strategy outlined as part of this study
- Utilities shall formulate specific capex schemes as outlined in the present report and seek approval of the same from the State Electricity Regulatory Commission (SERC)
- Utilities shall adopt an integrated planning approach for distribution network planning based on new planning indicators from increasing the grid penetration of DERs



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Organisational Profile

Idam Infrastructure Advisory Pvt. Ltd. (Idam Infra), an ISO 9001:2015 certified company, is a company engaged in advising Project Developers, Electricity Regulatory Commissions, Government Departments and Ministries, Lenders, Banks and Financial Institutions and Multilateral Agencies on a wide range of issues in the power sector.

Since its inception in 2007, the team at Idam Infra has gathered multitude of experience along with rich insights in policy formulation and analysis, regulatory framework design, commercial diligence, financial structures and corporate strategic aspects across the value chain of the energy infrastructure, especially in the market assessment studies.

Further details can be accessed on company website: **www.idaminfra.com**

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