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**Team Name:**

Shamsi Tawani

**Challenge:**

Load forecasting  
Predictive maintenance  
Customer/Consumption insights

**Technology:**

Big Data, Artificial Intelligence  
Other

**SDGS:**

Affordable & Clean Energy

**PROJECT SUMMARY:**

The project aims to develop analytical techniques to assess residential solar PV hosting capacity of power distribution networks by leveraging existing network and customer data. Additionally planning recommendations will be developed to increase the hosting capacity using non-traditional solutions that exploit the capabilities of PV inverters, voltage regulation devices and Battery Storage Systems. Existing PV penetration levels are around 5 percent in Pakistan which are mostly at the medium and low voltage networks. However the penetration level is increasing and new challenges for distribution network operators-DISCOs are arising. This includes increasing voltage levels, bi-directional current flows and loading of electrical infrastructure like transformers, capacitors and switches. Therefore DISCOs shall be equipped with analytical tools and framework to assess PV hosting capacity for operation and planning of each feeder. Every feeder is different from others, based on electrical parameters like line-impedances, X to R ratio, loading, number of customers, types of loads, LV networks, transformers, voltage regulators and capacitors etc. In order to develop such analytical tools we need accurate feeder data including nodal active and reactive powers and voltages. Exploiting high resolution smart meter data can unlock many opportunities for operation and planning. However this is not possible due to minimal installation of smart meters at customer level by DISCOs. Therefore we shall augment this data with power flow analysis for MV and LV networks by power systems simulation software like GridLab-D. This hybrid data can be used to estimate hosting capacity using linear regression models. Resource efficiency is achieved.

**CONTEXT OF THE PROJECT/INITIATIVE:**

Increasing electricity prices and a global pursuit for clean energy has accelerated adoption of renewable resources including solar PV and wind. However with this adoption, several challenges are arising for power network operators. Some of the key challenges are rising voltage levels, overloading of network and generation of surplus energy during off-peak hours which worsen the demand profile of DISCOs. To mitigate the impact of rising PV penetration levels, utilities shall be equipped with proper analytical tools for operations and planning. High resolution, customer level information of active power, reactive power, current and voltage is necessary to develop proper estimates for hosting capacity of each feeder. These estimates would help utility for operations and planning of distribution networks like installation or removal of voltage regulators, capacitors and transformers with online or offline tap-changers. Although smart metering data can unlock many opportunities but its installation at customer level requires huge investment and maintenance at the DISCO level. Scarcity of metering data is a challenge. However this scare data can be augmented with MV and LV network modeling using power flow analysis performed by power system software like GridLab-D. To develop customer level data we need to model the feeder with line impedances, X to R ratio, network elements and customer load profiles. At present we only have 5 percent of PV adoption, so we need to follow PV uptake trends for estimating hosting capacity for the years ahead. For accurate estimation of hosting capacity, data horizon is set to 10 years.

**DESCRIPTION OF PROJECT OBJECTIVE:**

Over the last two decades, power systems in general and distribution systems in particular have witnessed revolution with increasing penetration of renewable resources, intelligent fault indicators, battery energy storage systems and controllable loads. The distribution system has transformed from passive to active with consumers changing to prosumers. Distribution companies are facing several challenges amid this transformation. They must be equipped with analytical tools for operations and planning. The distribution feeder is evolving into smart grid and the role of ICTs is significant. Availability of high resolution network data down to customer level and improvements in data analytics, machine learning algorithms and computational capabilities are vital for developing work flows for distribution companies. The estimation for PV hosting capacity is modeled based on linear regression. A better correlation exist for large data set and PV uptake. The model can first be trained to make an estimate for upward adoption of PV systems. The objective of proposed project is to utilize smart meter data along with MV-LV network models of a feeder to estimate PV hosting capacity. This would result in an analytical framework to assess PV hosting capability under each feeder. We can develop case studies for two categories of feeders like urban and rural and further divide them according to lengths. This would help a distribution company to manage operations and planning with the increase in solar PV uptake by consumers. This would provide a useful insight into capacity building for the distribution company.

**SCOPE AND IMPLEMENTATION ACTIVITIES:**

The scope of the project includes development of analytical techniques to assess residential solar pv hosting capacity of distribution system. We would use hybrid data acquired from smart meters and MV-LV network modeling to construct a statistical regression model for each LV network, in a given MV feeder, and estimate its corresponding PV hosting capacity. Although smart meter data is available for customers with PV system installations with in a feeder but it is not possible to extract meaningful correlations between the PV penetration and its effects on network. This can only be captured by historical data that covers the evolution of PV penetration in time. Historical demand data from smart meters and irradiance profiles can be used to run three phase unbalanced power flow simulations along with feeder data for MV and LV networks to generate Voltage at each node. OpenDSS and GridLab-D are both open source power systems simulation software. They can provide time series model of MV and LV network. In this way we can have a large amount of temporal data over 5 years of time horizon considering a steady evolution of PV uptake. Statistical techniques can be applied to find correlation of data with PV uptake. Machine learning algorithm can be applied on the generated data. A methodology would be proposed to produce a regression model to estimate the PV hosting capacity in any given LV network using the hybrid data. Dataset can train a regression model which would result in hosting capacity estimation model.

**INNOVATION:**

The project perfectly aligns with the theme of cleantech challenge. It is a novel idea where the use of augmented smart meter data can provide an estimate into pv hosting capacity of a feeder. The use of power systems software like openDSS would solve the power flow equations and provide end customer level data on power, voltages and currents. We would deploy PV uptake trends, uptake rates in percentages, smart meter data, historical load profiles of consumers and feeder model to extract hybrid smart meter data. This data would be used develop estimates for the hosting capacity. This work has a strong correlation with current social and economic condition of our society. Our distribution system is witnessing adoption of solar pv systems at middle voltage and lower voltage residential levels. However, DISCOs lacks any analytical tool for assessing the hosting capability under its feeders. Hosting capability is defined as the maximum amount of solar pv that a given distribution network can host with out affecting its normal operation at any point in time.

**IMPLEMENTATION AND COSTS:**

As per the theme of cleantech data analytics would be performed on hybrid smart meter data to estimate solar PV hosting capacity at the distribution system. The expected software tools for the project includes Matlab, python, openDSS and mysql database. This project has enormous benefit for distribution systems operators like DISCOs for operations and planning.

**EXPECTED RESULTS:**

We would run the data analytics on several types of feeders including urban and rural, short and long and over loaded or underloaded. Conclusions and inferences would be drawn based on the acquired results.

**ABILITY TO SCALE:**

Yes, the proposed project has an excellent scalability. The developed framework can be extended to any size of distribution network. Infact larger feeder would provide an accurate estimate for PV hosting capacity due to a large amount of data.

**Team Members:**

| **S.No** | **First Name** | **Last Name** | **Gender** | **Email** | **Phone** | **Role** |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | Talha | Hassan | Male | 18060043@lums.edu.pk | 00923004133948 | Lead |
| 2 | Muhammad | Shamaas | Male | 18100217@lums.edu.pk | 03304102452 | Member |

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