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Managing intermittency of Demand & Supply at Electricity Distribution-level

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Concept note

Renewable energy (RE) integrated at the bulk-power transmission level and as a distributed energy resource (DER) assumes prime importance in India's transition towards a low carbon future. India has shown greater commitment to reduce its emission intensity from the electricity sector, which is reflected in its ambitious target of achieving 175 GW of grid-connected installed capacity from renewable energy sources by 2022. A significant quantum of power will be injected into the distribution network. The government of India has set a target of installing 40 GW of solar photovoltaic (PV) generation capacity from rooftop mounted systems of which approximately 3 GW has been achieved till date for realizing its mission of sourcing 100 GW (of the 175 GW) from solar PV by 2022, including a cumulative RE installed capacity of 275 GW by 2027 as per the National Electricity Plan, 2016. TERI has estimated a capacity addition of approximately 350–400 GW by 2030 under its on-going initiative called 'Energy Transitions Commission India'. The recent remark by the Prime Minister at the UN Climate Action Summit has raised the ambition of RE target to 450 GW. In another significant development, the union government has approved Phase II of 'Grid-Connected Rooftop and Small Solar Power Plants Programme' for achieving a cumulative capacity of 40 GW rooftop solar (RTS) plants by 2022. In Phase II, the aim is to implement the programme by making the distribution companies (DISCOMs) and their local offices the nodal points for administering and monitoring the RTS programme in each state and union territory. Thus, the active involvement of DISCOMs in feasibility-assessment, installation and commissioning of RTS plants, management of the metering and billing mechanism, will give an impetus to the successful ground implementation of the scheme. Other significant schemes such as Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) and Faster Adoption and Manufacturing of [Hybrid] and Electric Vehicles (FAME) – Phase II, have put the impetus on faster scaling and adoption of de-centralized DERs like solar PV and EVs, respectively. The KUSUM scheme was launched in March 2019 with a central aid of INR 34,422 crore to provide financial and water security to farmers through harnessing solar energy capacities of 25.75 GW by 2022. The scheme aims to install 17.5 lakh off-grid and 10 lakh on-grid solar pumps and solar power plants of 10 GW in rural areas by 2022. The expansion of distributed renewable energy capacity through decentralized rural solar PV can also provide grid support to long rural feeders. Similarly, FAME will support the transition towards greener mobility and increase the number of electric vehicles (EVs) with an outlay of INR 10,000 crore for Phase II. With the incentives for setting up charging infrastructure also a component of the multi-tier incentivization approach based on batteries sizes and type of vehicle, the penetration of EVs in the distribution network is also set to rise.

Many studies have supported the various advantages associated with the increased incorporation of embedded generation in the power network. RTS can provide power locally, at the point of consumption, thus reducing the need for laying out new Transmission & Distribution (T&D) infrastructure. This will reduce the losses, thus enhancing the efficiency of power distribution. Higher penetration levels of solar power would help in satisfying the local demand during diurnal peak times, thus preventing DISCOMs to purchase expensive peak power. Solar PV, installed in a distributed set-up in the ground-mounted configuration, can also help in supporting the voltage-profile of long rural feeders and, simultaneously, power several agricultural pump-sets, as envisaged under the KUSUM scheme. EVs can also help in regulating the power flows through smart and coordinated charging, and can further provide ancillary services through vehicle-to-grid (V2G). However, with increasing penetration of DERs in the form of RTS and EVs, there are several technical challenges related to their integration with the network that are likely to emerge.

Increasing penetration levels of rooftop solar could contribute to increasing skewness in demand pattern that affects day-to-day system operation. Voltage magnitude deviations, power quality issues, and certain protection-coordination phenomenon are the likeliest outcomes of large-scale RTS penetration. Additionally, integration of a large number of distributed units such as EV-charging stations with the power distribution network could lead to congestion. The V2G feature could also provide an additional dimension of bi-directional power flows in the local network. Addressing these sets of operational challenges at the distribution level of the power system is a task in itself since the network was originally designed to allow unidirectional power flows. Hence, a changing paradigm of localized, instantaneous bi-directional power flows through various forms of DERs calls for extensive power system studies, both at the planning and operational levels to accurately understand the behaviour of distributed RE systems and EVs integrated at the distribution network level. Accordingly, it becomes imperative to study the anticipated technical impacts associated with the integration of such DERs at the distribution network level to improve the overall operational efficiency of power utilities, manage the load of distribution transformers, and ensure 24x7 quality power supply. Accurate models of distribution feeders, DERs, and the loads with the correct approach for distribution power flow studies are important to understand to possibly quantify such impacts. Grid integration studies usually cover the study of impacts – both at steady and in dynamic/transient states, due to integration of various DERs, as previously discussed. These also include the study of possible measures for DISCOMs to mitigate such impacts. Deviations in steady-state voltage magnitudes at each bus, power quality impacts, distribution of fault currents in the presence of DERs, and protection-coordination issues are generally studied as possible technical impacts. Once the technical impacts of various distributed renewables and EVs are quantified and understood, it is equally important to model the various mitigation techniques to address those issues and study their effectiveness through similar power system simulation studies. This would help the distribution utilities to plan the operations of their network accordingly. Similarly, incorporation of models for On-load Tap Changers (OLTCs), smart solar PV inverters with appropriate droop characteristics and other measures would help in understanding their feasibility as mitigation measures. Similarly, sizing, rating of protection devices required to be added, and modelling of new protection-coordination schemes must be carried out to study the impact and mitigation in case of faults. The degree of impacts that a particular distribution network can withstand, without experiencing deteriorations in various parameters, outside their prescribed limits, often provides the DISCOMs with an idea of the allowable penetration level for each DER. Therefore, one of the major outcomes of such intensive power system studies through modelling and simulation is the quantification of the hosting capacity of a particular feeder.

In this context, TERI, with support from the MacArthur Foundation, has recently undertaken modelling and simulation studies for a few distribution utilities in India that include Andhra Pradesh Southern Power Distribution Company Limited

(APSPDCL), West Bengal State Electricity Distribution Company Limited (WBSEDCL), Chhattisgarh State Power Distribution Company Limited (CSPDCL), and BSES Rajdhani Power Limited (BRPL) in Delhi. Extensive modelling of the typical distribution feeders in each of the licensee's areas, selected in consultation with the utility, and a suite of power system studies have been performed to understand the various impacts of distributed renewables like RTS and EVs, and come up with possible mitigation measures. In addition to the software-based modelling and simulation, TERI has also performed on-site measurements to understand the impacts of EV on the power quality parameters of the local distribution network. The power quality impact studies were performed for CEA at the EV parking lot at New Delhi Municipal Corporation (NDMC) and at the headquarters of BRPL, where a fleet of EVs had been charged. The power-quality studies, supported by the US-India Joint Collaborative for Smart Distribution Grids with Storage (UI-ASSIST) initiative, have helped to understand the nature of power quality impacts due to both fast-charging and slow-charging of EVs, and have thus complemented the software-based modelling and simulation studies.

It is therefore imperative to bring together the perspectives of DISCOMs, power system researchers, regulators, policymakers, and present the associated key issues and potential solutions. To deliberate on the various modelling methods, possible mitigation measures, and the current challenges of various stakeholders so as to collectively find the way forward at the distribution level, TERI, with support from the MacArthur Foundation along with and the UI-ASSIST initiative, is organizing a thematic session titled 'Role of Battery Energy Storage System (BESS) in Electricity Distribution' on the sidelines of the World Sustainable Development Summit (WSDS) 2020 in New Delhi. The co-sponsors of the event are CESC Limited, BRPL, and BSES Yamuna Power Limited (BYPL). Highlighting the importance of such studies, the major findings by TERI would be disseminated during the discussion. Some of the major points of the discussion will highlight the possibilities of various mechanisms through which these studies could be taken forward by the DISCOMs to improve the aspects of training and capacity building.