Asia LEDS Partnership Grid Renewable Energy Community of Practice

Summary report of Session 4 on 'Grid Integration Studies for Variable Renewable Energy', August 29, 2018

The fourth online session of the Grid Renewable Energy (GRE) Community of Practice (CoP) was held on August 29, 2018 and was attended by around 25 participants. This online session was organized following the interest in the topic expressed by participants at the previous in-person GRE CoP session 3 held at the Asia Clean Energy Forum (ACEF) 2018, Manila, Philippines. The session focused on the basics, best practices, data collection and analysis that are carried out when conducting Grid Integration Studies.

Welcome and recap of GRE CoP session at ACEF 2018– Carishma Gokhale-Welch, LEDS GP Energy Working Group, NREL & Nikhil Kolsepatil, ALP

- GRE CoP's session 3 on 'Integrating Renewable Energy into the Grid: Opportunities, Challenges and the Way Forward' was held on June 6, 2018 at ACEF 2018. This in-person session built on the key concepts and findings from a deep-dive workshop organized by USAID, GIZ and NREL on June 5, 2018 on 'Grid Integration of Variable Renewable Energy'. Participants included government utilities representatives, power system operators, regulators, and representatives from technical institutions from Bangladesh, Bhutan, India, Indonesia, Kazakhstan, Laos PDR, Nepal, Sri Lanka, and Thailand.
- During the session, GRE CoP members were divided into two groups: one focused on policy and one on the technical aspects of RE grid integration respectively. Each group was asked to identify and present on the existing situation, challenges, and needs of countries in terms of integrating RE into the grid. Accordingly, members came up with country specific recommendations and way forward to enable renewable energy grid integration.
- As part of the group exercises the following topics emerged as priority areas,
  - Grid codes: establishment, timely updates to requirements, and enforcement of grid codes
  - Grid integration and distribution system studies
  - Implementation of incentives and compensation mechanisms to promote flexibility in grid operation
  - Competitive auctions for renewable energy procurement

Additional information on the GRE CoP session 3 can be found here.

Introduction to Grid Integration Studies - Ilya Chernyakhovskiy, LEDS GP Energy Working Group, NREL

A grid integration study represents a comprehensive examination of the technical challenges and potential solutions associated with integrating significant variable renewable energy (VRE) generation into an electricity grid. Grid integration studies are important for governments to use for development of the energy sector and to inform potential investors and private sector on the same.

Enabling elements or building blocks to develop grid integration studies include implementing known effective solutions such as forecasting, data collection, and modeling expertise.

Four phases of Grid Integration Study

There are four phases of a Grid Integration Study: 1) Data collection, 2) Scenario Development, 3) Analysis through modeling, and 4) Facilitation and Reporting. Important considerations include allotting time for data collection and preparation, and formulating scenarios that define potential pathways. In addition, several iterations may be needed to get the specific results. Stakeholder engagement is important throughout each step in the process to enable evidence-based policy making. These phases are necessary to arrive at results that are trustworthy and acceptable to all participants, and to ensure these are well synthesized to be understood by non-experts to inform energy policies.

Typical stakeholders in a grid integration study include wind and solar data providers, system operators, utilities, and transmission developers, RE plant owners/operators/developers, conventional plant owners/operators/developers, regulators and policy makers, and public advocates and consumer groups. Stakeholder consultation is commonly done through a Technical Review Committee (TRC). The TRC helps to ensure technical accuracy with high quality data, and contribute to a robust, credible, actionable study; link studies to industry concerns; reduce risk of being an academic study; ensure rigorous peer-review and input at all stages of the study; and to deepen understanding of priority RE issues and solutions among stakeholders. The TRC provides direction to the grid integration study and the modeling team and helps ensure that results of the study will be used in the decision making process. TRC's role is to assist in developing study parameters; review the modeling team's methods, data sources, assumptions, and other key issues; to interpret modeling results and link model outcomes with policy and regulatory processes; and overall to endorse the technical rigor of the study.

Data Collection

Some critical elements include gathering solar and wind resources data to analyze what is available in the country and the penetration of RE in the future; solar and wind system capabilities; water available for large hydro, thermal data for coal and gas plants, electricity demand (historical and projected); detailed data on the transmission system; operating practices for grid; operational constraints; and current and future availability of demand response and storage.

Scenario Development

A typical grid integration analysis has 3 to 4 scenarios, which might vary by extent of total renewable generation penetration evaluated, the ratio of solar to wind generation, mix of storage, rate of demand growth, etc. Meanwhile, sensitivity is generally an alternative operational practice or mitigation option to increase flexibility in the power system. For example, sensitivities can refer to the ability of a system operator to adjust load, to use demand

response resources, changing the size of a balancing area, fuel availability and prices etc. Sensitivities are applied to all scenarios and the results are compared relative to the base case (i.e. scenario without sensitivity options).

Analysis

Grid Integration studies can be categorized into three different types: i) capacity expansion planning ii) production cost modeling iii) technical stability/power flow studies.

Capacity expansion planning answers the questions: where, when, how much, and what types of generation and/or transmission capacity needed to meet RE targets at least cost. These studies are conducted for future periods ranging from 15 to 50 years.

The objective is to identify investment and decisions that minimizes the net present value for the future system. Their results provide optimal capacity mix for generation and transmission investments for each year in the study period. Examples of policy scenarios evaluated can include achievement of Nationally Determined Contributions, Renewable Portfolio Standard (RPS), and implementation of a Carbon policy or tax. Sensitivities can be informed by assumptions of fuel costs, load growth, and costs and efficiencies of technologies in the future. Latin American countries such as Argentina, Brazil, Colombia, and Uruguay have used capacity expansion studies to inform policy design, investments, and stakeholder engagement and public dialogue.

Production cost modeling helps to find out the system-wide operating costs and impacts associated with RE development and to understand the impacts of different flexibility options. These studies are usually conducted for a 1 year timeframe for a future point in time when RE targets are expected to be achieved.

Its objective is to assess the impacts of different penetrations of variable renewable energy on power system operations. Its methodology simulates the unit commitment and economic dispatch of a power system; approximates the daily operations of a transmission system operator; simulates an entire year of system operations; and calculates the cost of production electricity. Production cost models have been used by Kazakhsthan and India to assess future impacts of reaching their RE penetration targets.

Technical stability/power flow study is a detailed analysis of how the power system responds to a disturbance under various RE deployment scenarios and to assess if the system meets the reliability criteria. The timeframe can range from microseconds to minutes. Parameters such as regulation of frequency and voltage and transient stability of the power system in case of contingency events such as shutdown of a large generator or transmission line are assessed. In Ireland power flow studies have found a hard constraint on instantaneous penetration limits of inverter based resources. Regular power studies are performed to update results under different operational setups.

A number of modeling tools are available to support power system and grid integration analysis across different time steps and spatial scales. Selection should be appropriate to objectives of the grid integration study.

Reporting

Reporting of the study results may include technical reports, summary presentations, journal articles, publishing of underlying datasets, visualizations, and press releases.

Tips for conducting Grid integration studies include having clearly defined study questions (goals and objectives), early-stage identification of tools and models to be applied to answer the study questions, collection of data to enable quality analysis, transparency to make assumptions and results publicly available, and impartial peer review to endorse the study.

Integration of Renewable Based Generation into Sri Lankan Grid 2018-2028 - Randika Wijekoon, Electrical Engineer, Ceylon Electricity Board

Sri Lanka has a population of 21.2 million people with an annual per capita electricity consumption of 603 kWh. The country has an energy mix of mostly hydro (3,014 GWh), coal (5,071 GWh), Oil (5,045 GWh) and other RE (1,489 GWh). Installed capacity of variable renewables is as follows: wind (128MW), solar rooftop (150MW), and solar grid scale (50MW). The primary objective of Sri Lanka in conducting the Grid Integration Study was to determine how much VRE the country can reliably and economically integrate into its power system to achieve ambitious RE targets and to utilize available RE resources.

- Sri Lanka's Grid integration study consists of three main components: i) Capacity expansion study ii) System operational study and iii) Power system stability and power flow study
- The Grid integration study process started with a performance assessment of wind, solar, and hydro resources and their probable energy contribution to the energy mix in the different future scenarios.
- In the next step, renewable energy development and long term planning scenarios were determined. In long term planning, different combinations of RE were assessed to achieve the targeted RE capacities.
- The system operational study focused on medium term planning (yearly and monthly study) where hydro, thermal and RE dispatch and its optimization was studied with the help of optimization software.
- Short term operations (daily and hourly data): Dispatch optimization software was used to study energy dispatch in future time period.
- Power system stability study: A short term frequency stability analysis was carried out to analyze the impact of VRE, over a time frame of 100 seconds duration.
- Economic cost analysis was conducted to compute the most technically and economically feasible target RE capacities in the long term.

Key findings and recommendations from the Grid integration study of Sri Lanka

• Higher the penetration of RE (20-22% in case of Sri Lanka) would result in notable VRE curtailment
• Combination of lowcost base load, combined cycle and grid scale storage (pumped hydro) units were found to be the most technically and economically optimum expansion alternative for effective RE integration
• To establish wind and solar forecasting systems to the national dispatch center.

• To provide VRE curtailment rights to system operator
• Increase the flexibility of base load power plants
• Prioritizing the development of RE locations
• Adopting competitive bidding process for RE projects
• Minimizing the 'Take or Pay' risks of future LNG contracts

The study enabled average annual capacity addition of other renewables to be nearly four times higher than the past thus contributing to Sri Lanka's NDCs.

Future Improvements

Sri Lanka has invested into modeling the VRE curtailment requirement, impacts of existing conventional plants and the impact of pumped storage hydro power plants. It has conducted studies to assess the operating reserve requirement for future RE integration, temporal and spatial variability characteristics of solar PV applications and aggregated impact on the overall system. Sri Lanka also has plans to conduct a Distribution System Integration Study to supplement the existing Grid integration study and assess the impacts on power quality, reverse power flow, islanding, ground fault and transient, overvoltage, short circuit strength.

Discussion:

- The most time consuming part in conducting a Grid Integration Study is the organization of stakeholders, TRC, and data collection. It is recommended that a minimum of 1 year is allotted to conduct the study.
- To properly evaluate costs at the generator level and at the grid level, a production cost model or operational model is needed to look into fuel costs, maintenance costs, and other production costs of operating the entire grid.
- Decision makers are important stakeholders as the main objective of a Grid Integration Study is to influence enabling RE policies. Stakeholders that provide relevant data like utilities and RE developers are also essential.
- Stakeholders should be involved in making the assumptions of the study and should be approved and validated by them. They should also have inputs on how to resolve these uncertainties. The TRC is a useful avenue to provide feedback on such aspects.

Upcoming activities of GRE CoP:

- Based on specific interests of GRE CoP members, online sessions and resources are planned as follows:
    - Session 5 on RE Auctions in partnership with USAID Clean Power Asia – Oct/Nov 2018
    - Webinar on Grid codes in partnership with USAID Greening the grid is under preparation
      Date: 04 October 2018
      Time: 10:00 a.m. Eastern Standard Time | 7:30 pm India time
      Registration link:
      https://attendee.gotowebinar.com/register/6178821434249552130
    - Online session 6 on Grid codes – Q4 2018

- Learning resources along with members will be developed in the form of case studies and good practices
- Opportunities for country-to-country peer learning have emerged and no-cost technical assistance under the REAL service is available to members

Access further details and materials from the session:

Presentation

For any feedback or queries please contact:

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