Mitigating Effects of Renewables on the Grid

Renewable energy sources (RES) are increasingly being added to the electrical grid. As traditional fossil fuel-generated energy transitions to these renewable sources globally, challenges to the operation of the electrical grid arise. The amount of electricity supplied by RES is expected to rise to 62% of global electricity by the year 2050.[i] This white paper discusses some of the major challenges of RES integration with the grid and offers ways to mitigate them.

Traditional energy generation developed to supply energy as needed for the population served by the power provider. The energy is generated, transmitted, and supplied to customers with a specific voltage and frequency. When RES energy is being introduced into the electrical grid, it must have the same frequency and voltage as that of the grid. If it doesn't, it can cause voltage unbalance and negatively impact grid stability. Since RES often has a different voltage/frequency than that of the grid, the energy being produced by the RES provider can't be integrated into the grid without first being conditioned so that its characteristics are the same as the grid's energy. This necessitates that either the renewable source or the utility installs power conditioning equipment to ensure that the voltage and frequency of the RES matches that of the grid. Metering of the RES before integration is necessary to make sure the voltage and frequency are what the utility requires. Power and energy meters at the point of coupling can help to monitor RES voltage and frequency so that operators are aware of and can respond to any variations, e.g., blocking the RES integration if the unbalance is too great.

Reliability of the energy provided by the utility is extremely important. Reliability depends on high power quality. The energy needs to be free of harmonics, flicker, and other power quality problems. Power quality challenges can arise with RES. For example, solar, or photovoltaic (PV), energy uses electronic inverters to convert DC voltage to the AC voltage used by the grid. The inverters themselves can produce non-linear loads. "Non-linear loads draw in currents in abrupt short pulses. These pulses distort the current waveforms, which in turn generates harmonics that can lead to power problems affecting both the distribution system equipment and the loads connected to it."[ii] Additionally, "Power factor, also drops significantly with more [sic] number of induction generators connected to grid."[iii] To address the power quality challenges of RES, power quality monitors can be configured to analyze the RES energy and alert the operator of power quality issues. These can then be addressed before escalating and causing a power failure.

The need to supply energy for electric vehicle (EV) charging is increasing, as is the need to incorporate discharging from EV batteries back into the grid. The utility must be aware of how much energy is being transferred from the batteries to the grid and ensure that the energy has high power quality and good power factor. High accuracy metering enables the grid operator to monitor both the energy being discharged and its power quality. If power quality problems are found, the operator can take steps to minimize the impact and avoid escalation.

A related issue is the need for additional energy storage so that the grid can save the energy discharged from EVs as well as excess energy from PV, wind, and other RES. Since the amount of energy produced by RES is variable, being dependent on sunlight, wind, and other factors, there are times when RES can supply more energy than the grid needs, and other times when it is not producing any energy. Expanding the utility's storage capacity addresses both these issues and prevents either a surge in electricity, or a

deficit. It also avoids the economic impacts of more supply than demand. i.e., lowering the cost of electricity, which can be detrimental to the utility.

Many of the places where RES are easily generated are far away from the populous areas where the electricity is being used. This can be weather-related – putting wind farms in windy places on tops of mountains, or logistical - placing solar farms where the space they take up is not a problem for the neighbors. Transmitting RES energy for long distances can put a strain on the grid's aging transmission architecture. While creating more transmission lines is a possibility, this can be an expensive option. It can also be cumbersome as utilities can be reluctant to allow RES providers to build on their land. Another solution which is gaining popularity is using the energy where it is generated. Distributed RES generation could take place on a smaller scale so that the energy can be used without necessitating long transmission distances.

A related issue is that an electrical grid with many moving parts consisting of traditional and renewable sources of energy requires grid operators to be always aware of grid conditions and able to respond quickly as conditions change. An advanced energy management system that provides real time readings, alarms, and comprehensive power quality analytics can supply the needed information. Meters that can integrate with older DNP or newer synchrophasor systems can help to provide a system-wide view for grid operators. Problem areas can be isolated before they impact the rest of the grid, causing a power outage. Grid operators can take rapid action based on real time information to ensure the grid remains reliable and operational.

In conclusion, RES integration into the grid presents unique challenges for utilities. As the amount of RES being introduced into the grid rises, there is a pressing need to address the challenges. Some solutions discussed in this paper include metering to ensure voltage and frequency stability before integration, power quality alarming and analysis to address power quality and reliability issues, distributed RES generation, and advanced energy monitoring applications. Electro Industries/GaugeTech (EIG) offers advanced energy meters with real time measurements and alarms, power quality monitors that can also act as phasor measurement units, and AI driven energy management software for grid applications. For more information, visit EIG's website at www.electroind.com.

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[i] "Challenges of Integrating Renewables into Today's Power Grids," accessed 2/24/2024 from https://ratedpower.com/blog/challenges-integrating-renewables-ower-grid/.

[ii] "How do Linear and Nion-Linear Loads Differ?", accessed 4/24/2024 from https://www.riello-ups.ie/questions/39-what-s-the-difference-between-linear-and-non-linear-electrical-loads.

[iii] "Issues, Challenges, Causes, Impacts and Utilization of Renewable Energy Sources - Grid Integration," Er. Mamtha Sanhu, Dr. Talik Thankur, accessed 4/24/2024 from https://www.ijera.com/papers/Vol4_issue3/Version%201/DH4301636643.pdf.