Smart Inverters: Revolution or Evolution

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Meet the Author:

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The grid today is changing in ways that we cannot imagine. We are slowly moving away from a generation that came from large centralized power plants to generation mix that looks quite different. As the older coal-fired plans are being retired, an increased amount of generation is coming from renewable sources.

Key characteristics of renewable sources of generation are:

- *Varying output from a power perspective*
- *Varying output from a voltage perspective*
- *Varying output from a frequency perspective*
- *Some of the technologies deliver their output in DC*
- *Most renewable sources of energy are not dispatchable – they basically deliver power to the grid when they are generated.*

Given their diverse characteristics, integrating them into the grid can be challenging. And given their locations at the remote end of the feeder, these characteristics can have a serious impact on grid voltage quality and stability and also on safety.

Enter the inverter:

The first order of business is the need to figure out a way to connect renewable forms of energy supply to the grid. The basic connection needs are to be able to manage variable frequency, and variable voltage outputs to a grid that runs on AC and demands to be connected with a fixed voltage class (based on the KV-class of the equipment that it is connecting to) and a fixed frequency. For this to happen, a voltage inverter is needed. Here is how it will work.

- *DG systems such as wind, micro-turbine, or IC engine, generate AC output, often with variable frequencies - An AC-DC converter is needed in this case.*
- *DG systems such as PV, and fuel cells, generate DC output - A DC-DC converter is typically needed here to change the DC voltage level.*
- *DC-AC inverter is then needed to convert a DC source to grid-compatible AC power.*
- *Bi-directional smart inverters are needed to convert the power generated from DERs to serve microgrid load or connect to a larger grid*

These devices do not allow controllability of the power output, but they just allow these renewable sources of power to integrate with the grid. The entire objective of the inverter is its ability to convert the input power to something that will allow the connection to the grid. These inverters are also supposed to have the right sets of protection to protect the grid from being unduly impacted. However, this is not enough. For renewable power sources to truly make an impact on the grid, they need to have functions that allow them to replace the centralized generators.

Make way for the Smart Inverter:

Smart Inverters are a new set of technologies that enhance the ability of the inverter to control the output of power into the grid. This means that they need to be able to provide new services such as (1) Voltage support, (2) Voltage and frequency ride through, (3) Two-way control through automation and integration with SCADA and (4) Integration with storage. Let us look at these in more detail:

- *Active Voltage Support allows the inverter to become a localized source of reactive power (VAR support) to correct voltage and current imbalances that are inherent to the distribution system. For the longest period of time, VAR support has been provided by capacitor banks and voltage regulators. Including VAR support in a dispatchable manner allows the implementation to result in significant cost savings, while enabling more effective network support with improved local power quality and distribution efficiency.*
- *Voltage and frequency ride-through allow the Smart Inverter to better manage its response to temporary faults. When the basic inverter sees a fault, it disconnects from the grid and the renewable course of power that it is connected to. This action is not good. The ride-through feature allows the inverter to address this deficiency by providing localized voltage and frequency suppression support and so, increasing overall grid reliability and increasing PV system uptime.*
- *With increased penetration of renewable sources of supply, there is immediately a need for enhanced monitoring and control that is necessary for the integration of the grid to result in a reliable grid. These new levels of support allow plant and inverter-level monitoring and control of the output power in addition to integration with storage which is becoming increasingly affordable.*

CA's Smart Inverter standard:

On December 18, 2014, the California Public Utilities Commission (CPUC) adopted Recommendations for Updating the Technical Requirements for Inverters in Distributed Energy Resources, which establish new standards for advanced inverters under California's electric interconnection tariff known as Rule 21.
Under the ruling, California's investor-owned utilities must install advanced inverters the later of December 31, 2015, or 12 months after the date that the Underwriters Laboratory approves new certification standards regarding: default voltage ride-through requirements; anti-islanding protection for new voltage ride-through settings; frequency ride-through settings; dynamic volt/var operations requirements; ramp rate requirements; fixed power factor requirements; and reconnection by soft-start methods.

California's new standards draw from the European Union's experience utilizing solar PV inverters to provide reactive power support. In Europe, advanced inverters have proven to be one of the most cost-effective improvements for the reliability and efficiency of the power grid when paired with distributed generation. Similarly, delays in implementing advanced inverter functionality in some parts of Europe have led to avoidable upgrades and some inverter retrofits. Proactive implementation of new standards for advanced inverters in the U.S. will accelerate the transition towards cost-effective local renewable energy generation.

Conclusions and closing thoughts:

Smart inverters offer significant benefits to the power grid, including improved reliability and efficiency. They also support easier and lower-cost interconnection of distributed generation because of their ability to monitor and respond to grid conditions. They also allow a deeper inflow of supply from renewable sources which is a good thing for energy, the environment, and for the greater good.
Revolution or Evolution, it is moving the dial in the right direction.