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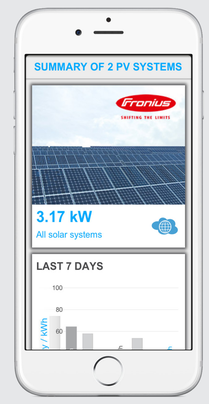
SHIFTING THE LIMITS

# A QUICK LOOK AT SMART INVERTERS




**TECHNICAL ARTICLE**

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## HOW INTELLIGENT INVERTERS, STORAGE AND INFORMATION TECHNOLOGY WILL CHANGE LIFE IN THE 21ST CENTURY

/ In the past 25 years, we have seen a dramatic change in the way we live our lives and do business. Enhanced mobility, connectivity and data processing capabilities have paved the way to a global and decentralized lifestyle. This development is mainly based on the tremendous technological progress but also reflects changes in society towards more individual freedom and how we get information.

Nevertheless, this transition in the way we live has a big impact not only on how much energy is consumed, but also when and where we need power. Smart phones and tablets are with us wherever we go. Therefore, energy storage applications are a part of everyday life already- we just barely recognize the fact because we are so used to it.

The scheme of decentralization of energy consumption is also reflected in the efforts for a smarter grid in the introduction of alternative energy resources, especially for residential and commercial applications. This impacts the way we should think about the structure of power distribution on regional and national levels.

## THE INTELLIGENT INVERTER – A VITAL PART OF THE SYSTEM

/ Until recently, solar PV inverters have been understood as the “heart of the system” due to the fact that it is located at the interconnection between DC and AC sections of pretty much every solar installation. No matter which topology is deployed, that bottleneck determines the central role such devices play in utilization of solar energy.

/ Conversion of DC to AC has been the main task right from the advent of inverters for grid tied applications; and over the years, reliability, efficiency and monitoring capabilities have rapidly progressed. It has taken the industry quite a while to realize that it has a “silver bullet” at its disposal, offering features ready to unleash additional revenue streams.

**SMART GRID READY**

Soon after Advanced Grid Features were introduced as a means to mitigate high PV penetration scenarios, utility engineers found more applications for functionality provided by smart inverters. These applications not only establish the “good resident on the grid” perception the solar industry was looking for, but they also put distributed energy resources (DER) on the map of grid operators.

To give an idea about such applications, let’s look at two examples illustrating the mechanics and values of these Advanced Grid Features (AGFs).

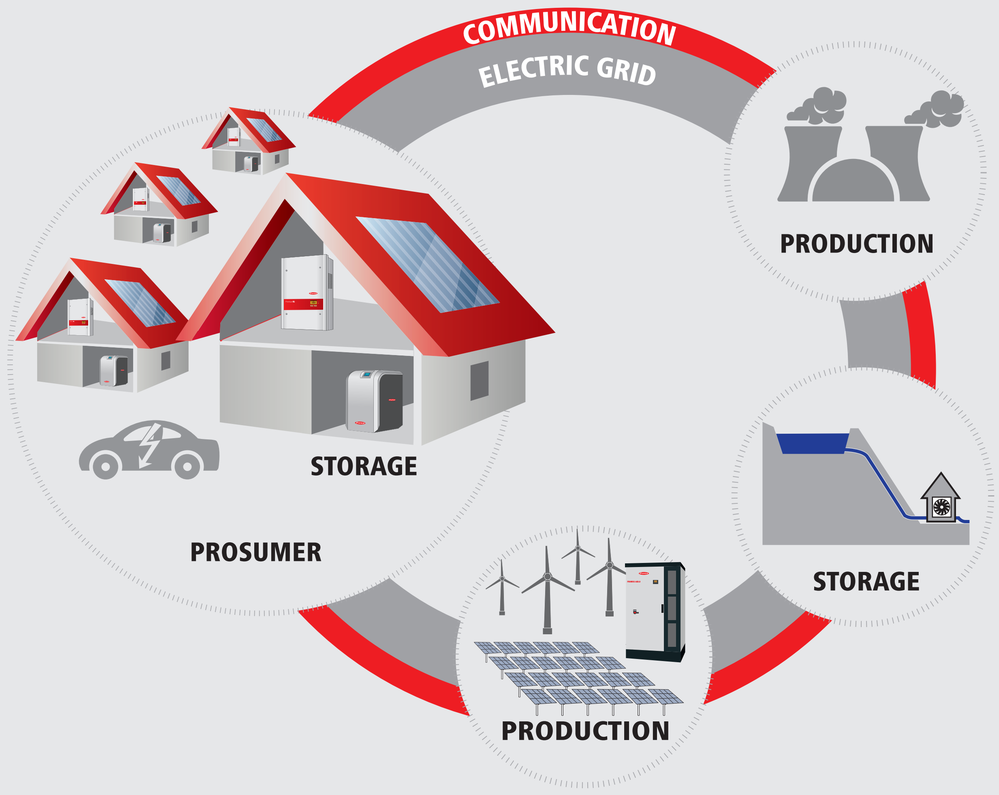
## VOLT/VAR - CONTROL

Physics teachers often use the water distribution system to visualize the flow of energy through an electric circuit to students. Commonly, the water pressure is presented as the equivalent to electrical voltage where-as electrical current is described as how much water flows through a pipe at a given moment. Let’s stick to this analogy for a while: in order to provide sufficient amount of water coming out of the faucet, the pressure needs to be at a certain level. For example, the longer the pipe system in a high rise, the more power at the pumps is needed to establish decent flow at the points furthest away. But if the maze of pipes is running far and wide, we might face the dilemma that the pressure is too big to close the pumps while there is still not enough through at the very end. The same situation is pretty much true for far reaching feeder lines. The grid operators are required to establish a certain level (e.g.+10/-12% of nominal value) of voltage – “pressure” throughout the whole feeder system.

/ This can be challenging, especially in far stretched distribution networks like rural areas. Traditionally, utilities coped with such scenarios by changing taps on transformers and capacitor bank devices. Those strategies work well but call for huge investments not necessarily providing revenue and, even worse, are rather inflexible to changing situations on the particular feeder (varying loads, extension of system, new customers....). Smart inverters, with their capability to provide “reactive power” by putting voltage and current “out of phase” on the mains come to rescue! Not going into the mechanics of AC distribution (also referred to as vars as reactive power) provides the means to control the voltage on the feeder. Being solid state devices, the injection of vars by intelligent inverters can be done in a highly controlled and scalable way.

## VOLT/VAR - CONTROL, CONT.

And there is more good news about var support by smart inverters: this valuable feature can be deployed even without constant communication to the gird operators. Pre-set volt/var schedules provide proper voltage levels right at the point where the PV system is sitting on the feeder line. As the name of the particular function implies, the amount of injected vars is determined by the actual voltage on the mains. Therefore, volt/var leads to a just-in-time proper regulation of the voltage on the feeder - quick, smooth and automatic with the help of the smart inverter.




## FREQUENCY/WATT CONTROL

/ Back to our classroom analogies. In an AC electricity distribution systems, small or large, the frequency is the indicator if the energy is balanced well within the whole system. Unlike voltage, which varies throughout the grid, frequency is the same at any given point of the electrical infrastructure of a particular grid. Any deviance from the nominal frequency value (e.g. 60 Hz in the US) indicates an imbalance between loads and supply. As energy cannot be destroyed, too much supply due to a lack of load lets the frequency go up.

/ This phenomena can be compared to the RPM of an engine in a car going downhill. Likewise, low frequency, like low RPM when going uphill, is an indicator for a lack of energy available from generation and/or too much load. Smart inverters also have an ace up their sleeves when it comes to helping the grid operators to maintain frequency within healthy limits. Frequency/Watt is the function that controls the energy coming from the particular solar system. So if the frequency is increasing, output from the inverter (power measured in Watt) is reduced accordingly which in turn helps balance the energy within the grid.

/ Energy storage systems that are able to “push” otherwise absent energy into the grid on short notice help prevent low frequency situations. Since static inverters use semi-conductors, unlike the classic generator, they have no mechanical limits when it comes to over/under frequency operation. Intelligent inverters are the logical 21st century component to the well-proven rotating machines electric energy distribution has been relying on for more than 150 years.

## FREQUENCY/WATT CONTROL, CONT.

The real power of such a function comes when all the smart devices within a grid act in parallel. As we know that frequency is a common factor throughout the system, all intelligent inverters contribute to grid stability when given the correct settings - even autonomously. Development is underway to gain utility engineers remote access to smart inverters and storage systems. In doing so, “aggregated DER” can be handled as virtual power plants with all different kinds of grid stability and control features. Therefore, smart inverters, energy storage systems and other forms of distributed energy resources (DER) will become valuable grid assets. With value comes monetization of functionality - an important factor for future business models supported by alternative energy sources.

## CONCLUSION

/ These are already functions already available with existing inverters today. Again, inverter companies are looking to the demands of the grid of tomorrow, the prosumer’s energy needs, and how they all work together.

## CONTACT US

/ If you have any questions about this or if you want to learn more about our solar solutions, do not hesitate to contact us at (219)734-5500 or PV-Support-USA@Fronius.com. We are happy to help you!

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