Power to the people

POWER ELECTRONICS WORLD
Connecting the power electronics community

While renewable energy is outpacing the growth of fossil-fueled power, it still must connect with existing and future utility grids. More than ever before, power delivery is multidirectional, with implications for all infrastructure levels. Mark Andrews technical contributor explains.

Power distribution once traveled a one way street. Large utilities—public and private—generated power that consumers utilized; power distribution was an archetypal centralized system.

How power is generated and distributed changed when renewable energy measurably entered the world. By nature renewable energy is distributed, not centralized. Grids built around centralized models had to adapt.

By 2008 renewable energy was ramping to higher levels every year, but was still a blip in national energy budgets. Yet technological innovations were taking hold; many governments favored new energy resources independent of fossil fuels. Particularly for residential applications, photovoltaic (PV) systems offered greater efficiency and lower costs compared to other renewable resources.

The move towards distributed power models is still an evolutionary process; the road has not always been smooth. Electricity generated in distributed systems varies in quality and is more prone to faults and harmonic frequency distortions than power generated, conditioned and closely monitored by utilities. This is not to say distributed power is problematic, only that it has to be diligently monitored like other sources feeding the grid.

High Efficiency Power Management

Managing how power is distributed, switched, inverted, monitored and conditioned is a global enterprise. Following May's PCIM conference in Nuremburg, Germany researchers at IHS said just the silicon carbide (SiC) and gallium nitride (GaN) power semiconductor market will surpass $270 million (USD) in 2015. While SiC and GaN components hold great efficiency and power density potential compared to pure silicon-based solutions, silicon product makers are not retreating.

A major challenge for silicon products is delivering comparable performance to SiC and GaN. That could be changing as seen at PCIM 2015. Fairchild Semiconductor announced a fourth-generation discrete insulated gate bipolar transistor (IGBT) that it claims can reduce energy loss by 30 percent. In another approach, Infineon Technologies launched its new Intelligent Power Module (IPM) that integrates IGBTs, gate drivers, a heat sink, sensors, control

electronics and digital bus communications in one robust package.

These examples point to broader power electronics trends. First, silicon manufactures have gotten the message that sufficiently high efficiency can lure away customers. This threat drives silicon innovation. Second, the increasing integration of power components with sensors, control and communications functions shows that monitoring and controlling source power (grid, PV, wind, thermal and backup generators) is increasingly a part of commercial and municipal strategies—no one wants to lose power under any circumstance since that threatens everything from profits to life itself. This evolution in power management products also demonstrates the impact renewable, non-centralized power generation is having.

strong>Feed It, Store It, or Have It Both Ways

Moving from centralized to distributed power models at first meant that power ‘not to spec’ feeding into the grid tripped monitoring systems to shut-out that energy. This approach worked well when renewable energy feed-ins represented a fraction of one percent of the supply. But now that some countries generate a quarter of their power using renewables, and analysts widely predict these resources will dominate global electricity supplies by 2050, ‘just-say-no’ is not practical, especially since there are now methods to make sure power fed into wide-area grids is harmonized with grid-level power.

While some solar and wind systems operate independent of local power grids either by necessity or choice, in most cases a residential or community-level system is practical because power not used by owners is sold to their local utility. Ideas behind this equation gave rise to net metering, feed-in tariffs, (FITs) and similar combinations of policy and technology that maximize the effective use of renewable energy.

Solutions for delivering clean and reliable electrical power through the grid are complicated to say the least. Typical PV systems meet power needs during a part of each day. When the sun isn’t shining brightly, consumers need to either draw from stored power or pull energy from the grid.

Making the exchange of power a two-way proposition is where storage and grid-tie inverter technology really shine. Solar power should be consumed on-site to the extent possible because it benefits the system owner and frees both the owner and the electrical grid from having to deal with transmission or storage without waste. But more than a decade of widespread renewable energy growth has demonstrated that storing power has not been economically feasible in many cases. This is changing, and systems that maximize efficiency and lower costs are becoming more widely available. But for system owners not looking for total grid freedom, grid-tie inverters are ideal choices.

Although grid-tie inverter systems balance and maintain the flow of various renewable resources with grid power, almost all can balance storage and PV power with grid feeds/draws. Photovoltaic power is typically a ‘must-have’ inverter application because of PV’s value-driven popularity; it is simple to operate and maintain compared to other renewable resources.

Storing surplus power isn’t automatically the best approach to maximizing the usefulness of a system’s generating capacity. Recent advances do point to a future where better batteries including redox flow systems and lithium-ion will combine with high efficiency inverters and automated energy management software to deliver multifaceted solutions. But affordability will remain a key factor and unless system owners want total flexibility and grid independence, it’s clear that some PV systems will never add storage. Cost-effective, highly efficient grid-tie inverters are more critical than storage to most system owners, especially where capacity goes well beyond the scope of typical residential systems.

Inverters Coming of Age

A renewable energy systems’ central grid-tie inverter plays a key role for optimizing the use of generated power and is also a significant balance of system (BOS) cost along with storage systems. Like any manufactured product they continue to get better and more cost effective as systems evolve.

A variety of companies are serving the grid-tie commercial inverter market in recognition of the growing potential for inverters that go the extra mile to seamlessly connect renewable energy resources with grid power, batteries and other energy resources. Notable grid-tie and micro grid inverters include products offered by Eaton, Parker, Princeton Power System and Ideal Power.

Eaton's Grid Connect Energy Storage Inverter is designed for high efficiency utilization for grid-tie and battery applications. Featuring a transformerless design, it offers up to 98 percent efficiency and employs a state-of-the-art liquid cooling system that provides maximum component life and durability even in harsh environments. Parker inverters stress compatibility between grid and renewable energy alternatives and grid frequency stability; they also use either air cooled or refrigerant cooling systems. Princeton Power Systems' product line includes its demand response inverter (DRI) designed to support micro grid applications combining power management for grid power, battery storage, solar and AC generators as well as EV chargers.

The 'Ideal' Approach

One of the newest inverters to enter the mainstream is Ideal Power's products that use a proprietary 'Power Packet Switching Architecture' (PPSA), that the manufacturer considers a very different approach to power conversion. It is transformerless and utilizes a 100 percent indirect power transfer compared to direct power transfer found in most previous power converters.

A key component of Ideal Power's design is the system's ability to drive a large number of very fast bi-directional switches to eliminate most of the component bulk associated with many inverter systems such as transformers. Their approach also eliminates the need for refrigerant-based cooling systems. Due to its higher efficiency fan cooling is sufficient and products can be as small as one-eighth the size of comparable solutions.

As Ryan O'Keefe, Ideal Power's Senior Vice President of Business Development remarked, "We could not have built this inverter 10 years ago. This approach benefits both new and existing infrastructures. We've had customers who remodeled buildings and reduced their footprint for inverters from a large room area to a closet—it can be that small depending on the power it needs to handle ... A large number of systems are going into existing structures that need to expand to handle more power in less space."

Like several competing solutions, Ideal Power's inverters handle a variety of electrical power sources and balance grid power with renewable energy, EV charging station applications and even backup generators.

As O'Keefe noted, weight and size savings are important factors for the company's products. In one example, their 30 Kw product has a power density of 550W per pound vs. 309W per pound of a competing solution—in this case the weight advantage is nearly zero, but the power handling is more than 50 percent greater; footprint and weight advantages dramatically increase as power handling ability grows.

Being a software-driven system, Ideal's grid-tie inverters can be adjusted by the customer in the field for either 50 Hz or 60 Hz systems; the same 'box' can ship anywhere in the world and set-up to match regional power frequencies and voltages. Ideal Power's 30 Kw system offers 96.5 percent CEC and weighs 97 pounds, whereas one competing solution is as large as 650 pounds and requires specialized transport. The Ideal Power inverter ships by UPS; component cabinets can generally be handled by two or three persons without forklifts.

The size, weight and cooling system advantages offered by Ideal Power's products have caught the eye of distributors looking for more novel and efficient ways to deliver grid-compatible solutions to commercial operations. Gexpro has added Ideal Power inverters to its offerings, including a new battery storage solution Gexpro calls Battery Energy Storage Solution (BESS) that also involves LG Chem's lithium-ion batteries.

Looking Ahead

As renewable resources expand to fulfill global energy needs, more efficient storage systems and the grid-tie power

inverters will play an important role in maximizing the potential of distributed power. While higher efficiency, lower-cost PV cells help deliver double-digit growth, analysts expect effectively managing generated power through affordable storage and inverter technology will be essential to make sure power is economically available during periods when PV panels are not operating.

Energy needs to travel both to and from the consumer if we're to fully realize the potential of non-centralized, distributed power generation. What once was a one-way street is becoming more of a multi-directional thoroughfare. Systems that enable this transformation will be rewarded for taking global energy economies to places that were never before possible.