



◀ *Quivira Vineyards, in the heart of Dry Creek Valley in Healdsburg, California, was installed over a year ago and has worked reliably ever since.*

# Inverter selection: string vs commercial

By Tucker Ruberti

If the only reason to not use commercial inverters is because you've never used commercial inverters, you should reconsider.

Choosing the right equipment for any PV project can be challenging given the diverse and expanding range of product choices in the market today. One of the reasons that component selection can be so difficult is that each component needs to be selected based on how it will affect the entire system, but there are few tools available to make good system level decisions. One of the most challenging component choices is whether to use multiple single-phase residential inverters, commonly called "string inverters", or a single three-phase commercial inverter for small commercial three-phase projects in the 30-60kW power range.

## COST

Some buyers make their small commercial inverter choice based on cost. Others just buy what they have always used – residential designers and installers use residential products and commercial designers and installers use commercial products. But the choice of inverter can have a big impact on overall system cost, performance and lifetime. To make the right choice between string inverters and commercial inverters, a system level analysis is needed. Some of the most important system level questions to ask include: How is system level costs affected by inverter choice? How are reliability or power quality affected by inverter choice? and How is system level efficiency affected.

String inverters are typically less expensive per watt than commercial inverters. But the purchase price of the inverter is just a small part of the total system cost equation. Inverter choice greatly affects labour and balance of system costs. Reviewing the impacts on a typical 30kW

project provides a good example. If a commercial inverter is used, the solar panel would typically be wired to three rooftop solar combiner boxes and then brought down to the inverter using a single set of DC wires. From there a single set of AC wires would leave the inverter and be connected to a single breaker in the AC service panel. If the same 30kW project used six separate 5kW string inverters, then the installer would need to mount and wire six separate combiner boxes and bring down six sets of DC wires from the roof to the inverters. Then on the AC side, six separate wire runs would need to connect to six separate AC circuit breakers. Further, commercial inverters include integrated AC and DC disconnects as standard which further save time and money. However, string inverters only sometimes include DC disconnects, and AC disconnects are rarely included with string inverters. Finally, if data monitoring is required, there are added costs to connect six inverters to data lines versus running just one data line to a single commercial inverter.

Specific sites will have different cost characteristics, but the increased labour, parts and materials costs required for a string inverter installation makes commercial inverters no more expensive than string inverters from a system perspective, and may even reduce system costs. But cost should only be one part of the decision making process.

## RELIABILITY AND UPTIME

Ensuring reliability and uptime should be near the top of the list for most system designers, installers and customers. Some professionals prefer string inverters

because if one inverter fails then most of the system is still producing power. But consider the fact that string inverters have been built for residential markets which focus on maximizing the initial rebate by minimizing per watt installed cost. Because low cost is most important, lower cost components are used to stay competitive in a crowded market. On the other hand, commercial inverters are built for a market that competes on a performance-based payback model where a 20 year lifetime is expected and extended warranties of 15 years or more are common. For this reason commercial inverters are built with best-in class components and manufacturers compete on reliability instead of first cost. Which system is going to require more service calls and suffer more downtime – the system with six lower cost inverters or the system with a single inverter with the highest quality components?

## EFFICIENCY

Efficiency is another area where inverter choice has a dramatic system level impact. It is also especially difficult to estimate efficiency because the industry standard for measuring efficiency, the CEC (California Energy Commission) rating, does not represent real world conditions. Individual string inverters typically score a 94-97% CEC efficiency rating while commercial inverters under 50 kW are in the 92%-94% range for CEC efficiency. But real world string inverter efficiency can be very different than the contrived CEC efficiency rating system. In practice, it is far more difficult to achieve high system efficiency using string inverters because there are so many connections required. For example, string inverters usually require added series connections versus a single commercial inverter. Each series connection introduces an added voltage drop and a corresponding efficiency loss. Unfortunately no studies have been published yet to document this real world efficiency loss, but it is instructive that manufacturers who sell systems of packaged string inverters only quote individual string inverter efficiency and not total system efficiency.

Another consideration is that string inverters are single-phase devices and care must be used when applying them in a three-phase application. If the string inverters are not installed in groups of three with equal loads on each of the three phases, then the system power output is not balanced. Unbalanced output may decrease the amount of energy a PV system gets credit for producing and could cause nuisance tripping. It may also decrease power quality and violate utility interconnect agreements.



▲ PV Powered's PVP30kW commercial inverter is a simple, elegant design packed with standard features.

#### CONSIDERING THE SMALL STUFF

There are also other smaller differences that need to be considered. Data monitoring is a must for commercial installations. String inverters charge a premium for their data monitoring hardware and then charge again for the data monitoring services. However, some commercial inverter manufacturers include data monitoring hardware and sophisticated web-based analysis tools at no extra cost. Also, in terms of appearance, most people prefer the clean simple look of a single box with minimal wiring and integrated disconnects versus a wall of string inverters with separate conduits runs and disconnects. One looks like a commercial installation, the other simply looks like a mismatched problem and solution.

In summary, if the only reason to not use commercial inverters is because you've never used commercial inverters, you should reconsider. Commercial inverters will provide the reliability and efficiency that a commercial customer expects. Just as importantly, service calls will be kept to a minimum which is something that will make both customers and installers very happy. And, when all the costs are added up, commercial inverters will likely save money as well. Resources are available, including training and installation support from some manufacturers and distributors to help users, installers and designers evaluate the options and make the best possible selection for their PV application. Tucker Ruberti is Product Manager of Commercial Inverters Systems at PV Powered in Bend, Oregon. Tucker earned a BS in Industrial Engineering from Cornell University and an MS in Environmental Management & Policy from the Rensselaer Polytechnic University. He has worked in energy technology industry since 1993 while working for Westinghouse, General Electric, the New York State Energy Research and Development Authority (NYSERDA), Sunlight Solar and IdaTech. Tucker can be reached at [tuckerruberti@pvpowered.com](mailto:tuckerruberti@pvpowered.com).

■ PV Powered | [www.pvpowered.com](http://www.pvpowered.com)

## Ausra and leading utilities commit to large scale solar thermal electric power

Recently, in association with leading utilities FPL Group, Inc. and PG&E Corp., Ausra, Inc. presented a formal commitment at the Clinton Global Initiative Annual Meeting for a clean energy future through the development of 1,000 megawatts of solar thermal power plants that will generate 50 million megawatt-hours of clean power over a 20-year period. As part of this announcement, PG&E Corp. committed to purchasing an additional 1,000 megawatts of solar thermal power over the next five years. Separately at the Clinton Global Initiative Annual Meeting, FPL Group committed to develop 500 megawatts of solar thermal power plants. According to the company, collectively these commitments will generate about as much electric power as all the photovoltaic solar panels installed worldwide in 2006, and will prevent the emission of more than 73 million tons of carbon dioxide into the earth's atmosphere over 20 years.

"Solar thermal generation can deliver the majority of U.S. electric power and make major, much-needed reductions in the emissions that are changing Earth's climate. World-class partners like FPL Group and PG&E Corp. have decided that solar thermal technology can help deliver large-scale clean power at competitive prices. The name Ausra derives from an ancient word for the sunrise. Today we are witnessing the dawn of an industry that addresses several major national needs at once," said Ausra Chairman and Chief Scientific Officer David Mills.

"Solar thermal technology can scale up within a few decades to deliver over 90 percent of world electricity without carbon emissions and without raising prices for electric power. Electricity generated by an Ausra solar thermal power plant can be made available around the clock and reach capacity factors of 60 percent, just like coal and gas plants, and is expected to be competitive with current fossil generation and cheaper than next generation IGCC coal," said venture capitalist Vinod Khosla, a member of the Clinton Global Initiative Advisory Board and Ausra's board of directors.

■ Ausra, Inc. | [www.ausra.com](http://www.ausra.com)



▲ ersol's Jan Lossen. Just one of the individuals who played a part in the development of a new solar panel based on SuperSize cells.

specific investment is required, and due to the lower specific energy consumption in this pulling process, it allows the energy recoup time per Wp to be significantly reduced.

"In the ensuing production of the 210 mm x 210 mm square, 220  $\mu$ m thin silicon wafers, the high degree of automation and the improved edge-to-area ratio mean that the handling costs are lower than for production of the previous standard wafer size of 156 mm x 156 mm," explained Jürgen Pressl, ersol director in charge of the Wafers business unit.

The SuperSize cells were processed in the ersol Solar Cells unit in collaboration with SolarZentrum Erfurt. ersol was supported in application of the antireflection coating to the 210 mm solar cells by Roth & Rau AG. The 210 mm cells yield the same cell efficiency as the 156 mm cells, but 80 percent more power can be achieved per solar cell. In terms of factory production, this means 80 percent greater output using comparable production equipment. Processing of the SuperSize solar cells was further conducted in accordance with certain design specifications unique to cells produced exclusively for Day4 Energy. In particular this technology enabled ersol to use one less production step and economize as much as 40% of Ag printing pastes while increasing average solar cell efficiency at the same time.

The advantage of the high power generated by the SuperSize cells creates a new set of challenges at the module level. This is why Day4 Energy's participation in the project was further critical to achieving high conversion efficiency of the SuperSize modules. Day4 has optimized its proprietary next generation module technology of Day4 Electrode in order to take the performance of the SuperSize modules to the level that is practically impossible to achieve with conventional module technology, according to the company.

This technological collaboration shows the considerable cost reduction potential that currently exists in crystalline photovoltaics. Similar to the chip industry, unit costs can be reduced by increasing the size of the substrate (wafer). "We believe our project will provide a new impulse for the further development of cell standards within the photovoltaic industry," said Dr. Claus Beneking, CEO of ersol Solar Energy AG and board member responsible for technology. "This project is a demonstration of a strong potential for cost reduction that can be realized through a combination of leading edge technologies at the silicon ingot, wafer, solar cell and PV module levels.

These new high power PV cells from ersol clearly show their advantage when combined with Day4's next generation module technology, capable of collecting the enormous amount of power these cells generate," adds George L. Rubin, President and Chief Operating Officer of Day4Energy.

■ ersol Solar Energy AG | [www.ersol.de](http://www.ersol.de)

■ Day4 Energy Inc. | [www.day4energy.com](http://www.day4energy.com)

■ Crystal Growing Systems GmbH | [www.cgs-gmbh.de](http://www.cgs-gmbh.de)



▲ An Ausra plant in New South Wales, Australia. Ausra will use the same technology to construct carbon-free power plants designed to fulfill the commitment made at the Clinton Global Initiative. Their existing plant is at the Liddell Power station, providing high-quality steam to Macquarie Generation, Australia's largest generator. The new commitments announced by the company will lead to the construction of similar plants in the United States.

## Leading technologies come together to present SuperSize cells and modules at European photovoltaic exhibition

ersol Solar Energy AG (ersol) - in cooperation with Crystal Growing Systems GmbH (CGS), SolarZentrum Erfurt, Roth & Rau AG and Day4 Energy Inc., has developed a highly innovative solar panel based on SuperSize solar cells with an edge length of 210 mm in an R&D project. The project represents a combination of industry's leading technologies provided by each partner. Using equipment provided by CGS, the ersol Wafers business unit has developed a pulling process resulting in silicon crystals with a diameter of 300 mm. The advantage of this 300 mm ingot pulling process is the greater yield of wafer surface at a comparable pulling rate, thereby maximizing capacity utilisation per pulling plant. This means that less