The Commercial Promise of 1,000 VDC PV Design

The U.S. commercial PV market is primed for significant growth. According to GTM Research, the official research arm of the Solar Energy Industries Association (SEIA), the segment is expected to see a 25 percent annual compound growth rate from 2011 to 2016, clearly indicating the market's potential. While much of the growth has been attributed to plunging module prices, a new focus on inverter technology and design innovation in balance of system (BoS) components promises to drive the generated cost of solar electricity even lower.

BoS pricing can be relatively inflexible due to raw material costs. However, there is room for savings through new technologies and system design optimization. One such innovation, which is already applied as a standard best practice in the European commercial segment and utility projects around the world, has recently entered the North American commercial market—1,000 VDC design.

Using 1,000 VDC input design and technology allows integrators to realize increased energy production, material cost savings and a lower levelized cost of energy (LCOE). The barriers to domestic adoption have ranged from a lack of high quality UL listed products, legacy designs at 600 VDC and reluctant inspector acceptance. Recently, the tide has changed and these barriers have been removed by a growing number of high quality UL listed modules, BoS components and inverters driven mainly by the utility segment, along with a greater awareness among inspectors that provisions exist in the current code to support 1,000 VDC for commercial applications.

Clear Financial Benefits

The case for commercial 1,000 VDC adoption is clear. With higher voltages, integrators benefit from lower installed costs, greater inverter efficiency, less system power loss and reduced BoS components.

For comparison, consider the following benchmark between a traditional 600 VDC system and a 1,000 VDC system.

1 MW DC (1,117,800 watts)	1 MW DC (1,117,800 watts)
750 kW Sunny Central CP-US inverter	750 kW central inverter
4140 JA Solar modules	4140 JA Solar modules
1,000 VDC	600 VDC
20 modules per string	12 modules per string
207 strings	345 strings
9 combiners/home runs	15 combiners/home runs

Due to greater DC input and longer DC strings, the reference system achieves significant savings, particularly attributed to reduced wiring need. The following graph illustrates these savings.

BOS WIRING QUANTITY	600 V DC	1,000 V DC	DIFFERENCE
Modules (number per string) X (strings)	12 x 345	20 x 207	No difference
String combiner boxes, home runs	15	9	(6)
10 AWG wire module to combiner	46,618 ft	27,340 ft.	(19,278)
350 MCM wire combiner to inverter	4,703 ft	2,500 ft.	(2,203)
300 MCM wire	943 ft	1,466 ft.	523
4/O AWG wire	665 ft		(665)

By saving more than 19,000 feet of 10 AWG wire and 2,000 feet of MCM wire and cabling, the 1,000 VDC system saved more than $20,000 on wiring costs alone, not including conduit or labor savings. When all factors are considered, a $0.02 to $0.03/watt savings can be achieved at installation.

Improved Performance

Systems can achieve additional savings through better performance. Reduced line losses and higher inverter efficiency improve energy production, reducing the system's cost-per-megawatt hour.

Following the principle that higher voltages will experience less resistance, a 1,000 VDC system will perform better than a 600 VDC system. Comparing line losses through a voltage drop calculator showed the following for the same 750 kW AC example.

LINE LOSS SUMMARY	600 V DC	1,000 V DC	DIFFERENCE
Lost watts	10,435	6,390	(4,045)
Percentage of System Size	1.39%	0.85%	(0.54%)

With an approximate 0.5 percent efficiency gain due to lower line loss, total energy harvest is improved.

The same principle applies within the inverter. Higher voltage means less internal resistance. The current CEC efficiency record is 98.5 percent, held by the SMA Sunny Central 800 CP-US inverter—a 1,000 VDC machine. In comparison, most 600 VDC inverters will be 0.5 to 1 percent lower. Designers work very hard to find efficiency gain because they know it translates directly into a more profitable project.

Long Term Financial Advantage

How much is a 1 percent of gain worth to a project this size? We compared five sites across the U.S. using PVsyst, a PC software package for the study, sizing, simulation and data analysis of complete PV systems. Using the program's default values, PVsyst showed that the 1 percent gain could be worth more than $40,000 over 20 years at $0.12 per kilowatt hour. Columbus, Ohio, the least valuable of the five sites, showed a value of $28,000 while Tucson, Ariz., came in at more than $40,000.

With approximately 40 percent BoS wiring savings and up to 2 percent efficiency improvement, the economic value can top $100,000 per MW/DC ($0.10/watt). This is exactly why 1,000 VDC systems have been the preferred standard in Europe for several years. This technology and design standard has ability to appreciably drive price down and value up in North America. With code, inspector and equipment supply issues resolved, the future of 1,000 VDC domestic commercial PV is extremely promising.

For more information on leading 1,000 VDC system design visit the SMA Sunny Central CP-US Application Guide.

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