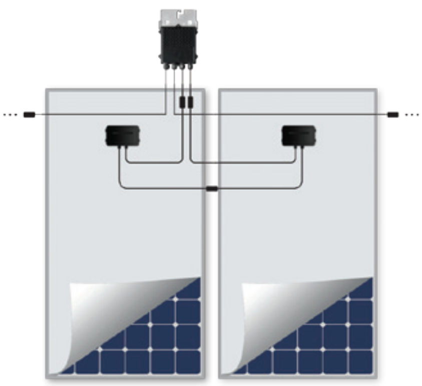
solaredge

OPTIMIZING COMMERCIAL SOLAR

SOLVIDA energy group

SolarEdge's optimized inverter solution was able to reduce the DC side electrical BOS costs to less than 1 cent per watt for a total savings of almost 50 percent when compared to conventional central inverters.



A study conducted by 3rd party engineering firm Solvida compared three inverter solutions: 600V central inverters, 1000V string inverters and SolarEdge's 3-phase commercial inverters. **SolarEdge demonstrated the greatest cost reduction in eBoS costs, nearly eliminating the DC-side eBoS entirely.** Furthermore, SolarEdge's warranty gives it the edge in total lifetime cost making it the best overall solution for a lower cost of electricity.

Inverter Selection Drives Significant Cost Implications

In 2013, for the second year in a row, U.S. commercial solar installations exceeded 1 GW. As interest continues to build for solar energy in private and public non-residential applications, SEIA/GTM estimate that annual commercial solar installations will exceed 3 GW by 2016. While previous cost reduction initiatives have been mainly driven by PV modules, future cost reduction is expected to come mainly from Balance of Systems (BoS) components. Areas like soft costs (permitting, site design, customer acquisition), electrical hardware and installation labor will require innovation to meet future costs goals. But cost reduction is not just about the raw cost of components. For example, inverter selection affects not only the price paid for the inverter, but also electronic Balance of System (eBoS) and labor costs. While the inverter cost is only around 10 percent of the total system cost, the total impact of inverter selection can represent around 25-30 percent (Figure 1).

U.S. Commercial Rooftop PV Breakdown, 2013

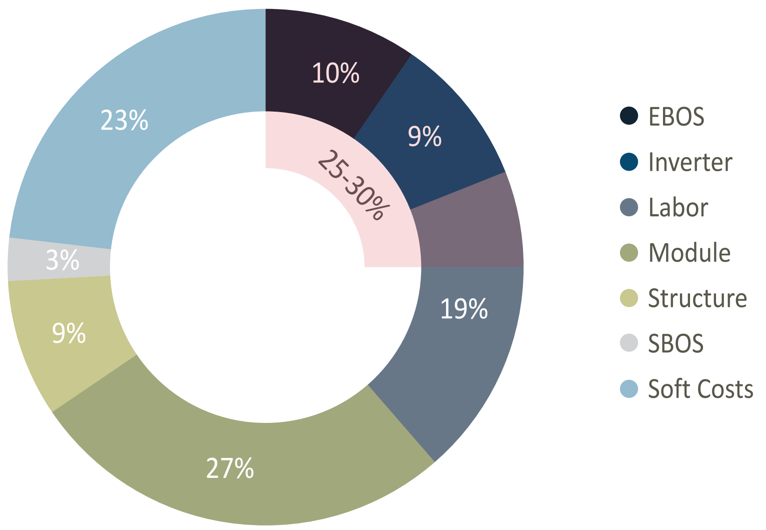


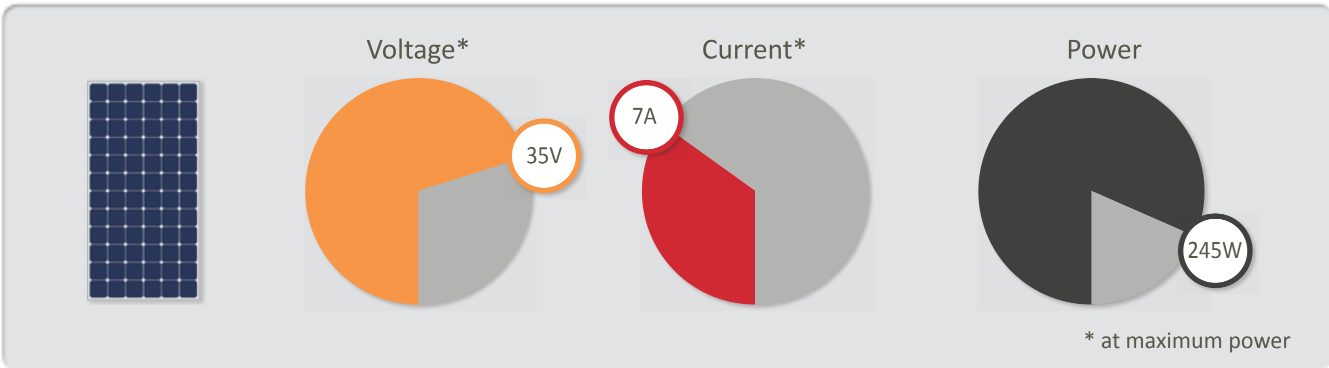
Figure 1 Greentech Media

To reduce eBoS costs, many inverter manufacturers have started to supply UL certified 1000V inverters to the US market. These inverters increase the number of modules that can be installed on a string and thus reduce the homerun wiring and combiner box requirements. String length in traditional string inverters is a function of the module voltage at open circuit, temperature adjusted for a region's coldest weather. Since module voltage increases at open circuit (relative to maximum power point) and voltage increases with lower temperatures, this represents the highest likely voltage that a PV module will experience. However, the implication of a higher voltage is a shorter string length. For 600V systems, a string of 72-cell modules may only reach 12 modules. With a 1000V system, the total voltage increases by 67 percent, meaning that the module count will also increase by this same ratio to 19 modules.

Module Level Power Electronics (MLPE), such as DC optimizers, work on another premise. Instead of increasing system voltage, they decrease module voltage. Some power optimizers help by clipping voltage at a level similar to the maximum power point voltage. This means that adjustments made for open circuit voltage and temperature can be negated. By clipping voltage, a power optimizer can increase string length by 30 percent.

However, SolarEdge power optimizers don't just clip voltage – they control the voltage. SolarEdge inverters work in an advanced Fixed-Voltage mode. The power optimizers receive power from the PV modules and output a total voltage equal to the optimal conversion voltage for DC to AC conversion. The total voltage of all module power optimizers is a fixed value governed by the inverter's current draw. With full control over the power optimizers' voltage output, SolarEdge is able to increase string length by over 100 percent. Three phase systems designed with SolarEdge can have strings of up to 12,750 watts. This means that each 20kWac SolarEdge inverter can be loaded with 25kWdc on only two strings drastically reducing system eBoS requirements.

Module Power (input): Voltage and current depend on module & environment



Optimized Power (output):

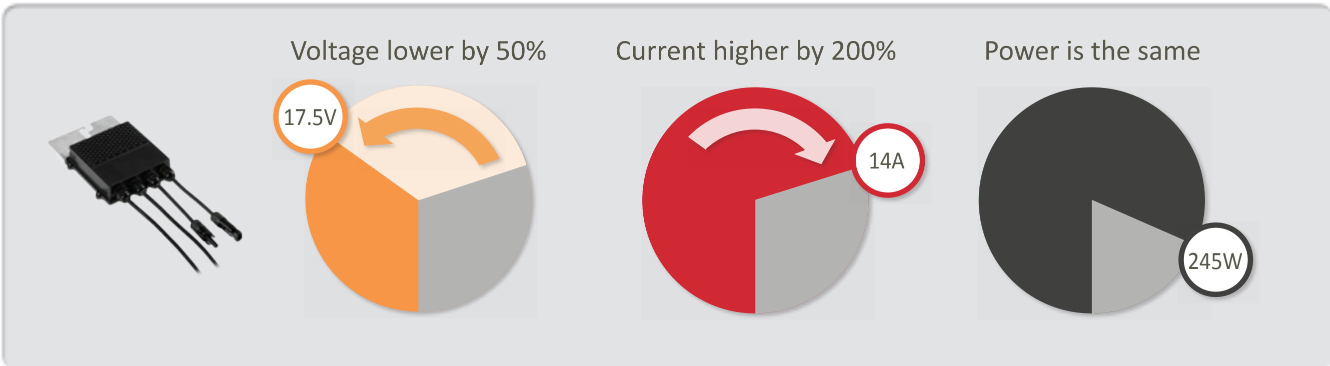


Figure 2

Base System Requirements

Solvida Energy Group, an independent third party engineering firm, conducted an analysis looking at eBoS for a 500kW commercial rooftop array in Bakersfield, California utilizing common installation practices with 1,680 72cell 300W modules (Figure 3). The study compared a 600V central inverter, a 1000V string inverter and SolarEdge's SE20KUS inverter coupled with P700 power optimizers that enabled a 2:1 connection of 2 72-cell modules in series to a single power optimizer.

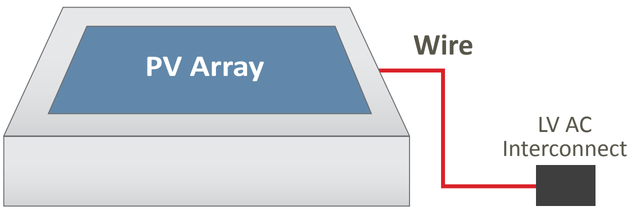


Figure 3

Option 1: 600V Central Inverter

Designed as a system that sits on a concrete slab on the ground level, the 600V central inverter must take the DC power from the roof top to the ground level and transfer AC power into a low voltage AC interconnect (Figure 4). Due to NEC requirements, the 600V central inverter can only support 12 modules per string resulting in 140 strings. A designer must include for each string: combiner boxes, fusing protection and an array Re-Combiner to combine the conductors from each combiner box before reaching the inverter. Each string of modules will also require cabling to reach from the combiner box to the start of the string and cabling from the end of the string back to the combiner. These cables are commonly know as 'homerun' cables. However, since the inverter is located at ground level, it can be placed near the low voltage AC interconnection resulting in relatively low AC eBoS costs. Solvida's analysis concluded that the eBoS on the DC side was $0.13/watt and the eBoS on the AC side was $0.05/watt, for a total of $0.18/watt (Table 1).

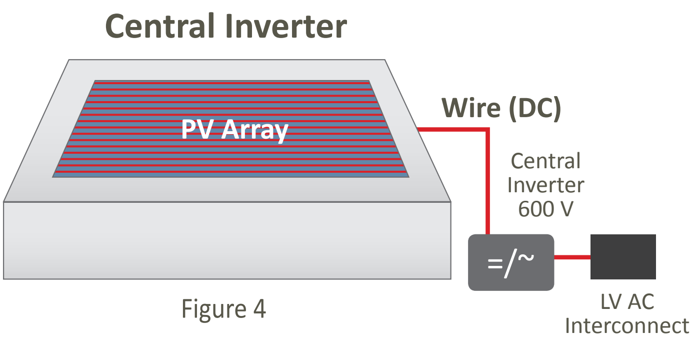


Figure 4

eBoS	c/W dc
DC Labor	6.9
DC Materials	6.1
AC Labor	1.2
AC Materials	3.4
TOTAL	**17.6**

Table 1

Option 2: 1000V String Inverter

Compared to a central inverter, a 1000V string inverter has more advantegous mounting options such as on the side of the building or next to the racking. In the study, the inverter was placed adjacent to the racking to lower the DC side cost as much as possible and to comply with NEC 2014 rapid shutdown requirements (Figure 5). The study modeled a 27.6 kWac transformerless 1000V inverter. The inverter included an additional cost for an integrated combiner option. This combiner option satisfied the requirements to fuse and combine the multiple DC strings. It is treated as a cost in the eBoS materials section for the assessment but requires no added labor to install. The 1000V string inverter enabled longer string lengths of up to 19 modules–an increase of almost 60 percent. The total number of strings was reduced to 90 strings on a total of 15 inverters. The longer strings reduced costs in homerun cabling and in combiner boxes while the inverter placement reduced the need for long DC runs to ground level. However, increases in the AC eBoS occurred to transfer power from the rooftop to the low voltage AC interconnection. With a 1000V string inverter, total eBoS costs were reduced from $0.18/W to $0.14/W–almost a 25 percent reduction. The DC costs reduced to less than $0.07/W while the AC costs increased to over $0.07/W (Table 2).

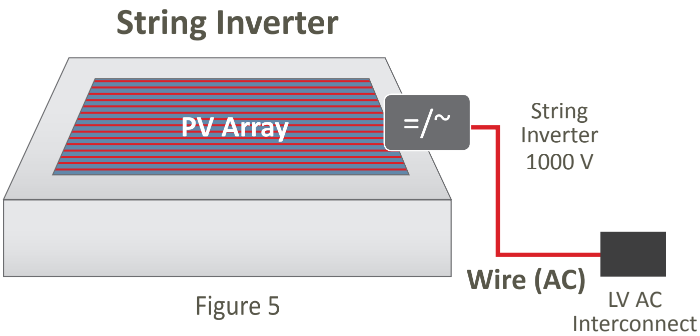
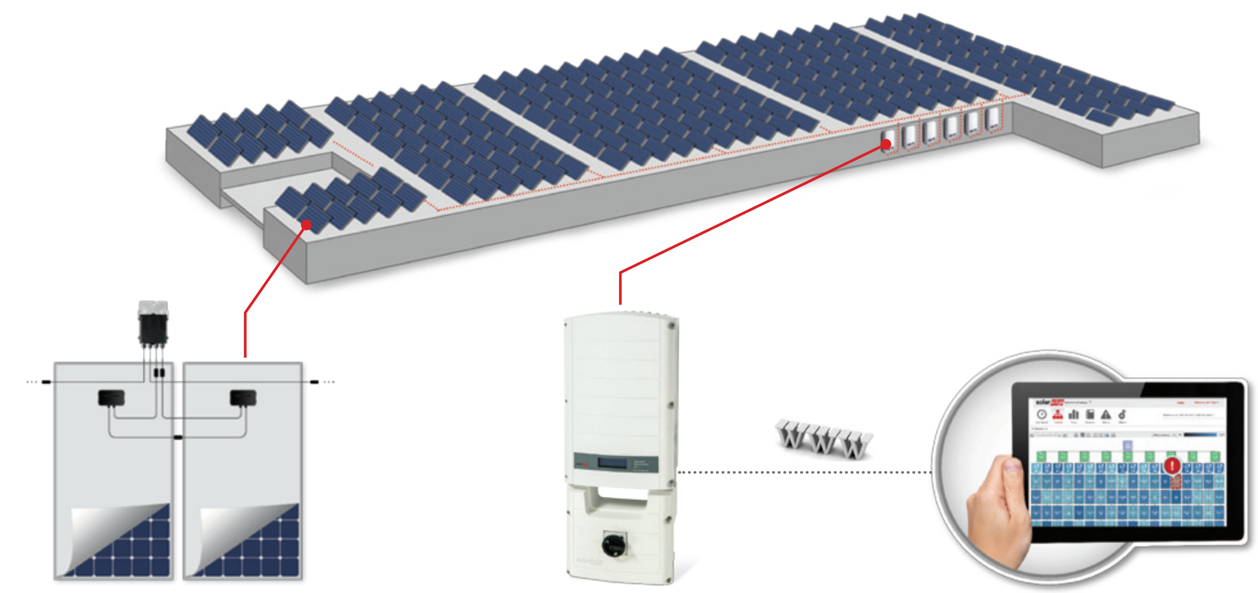


Figure 5

eBoS	c/W dc
DC Labor	2.3
DC Materials	4.2
AC Labor	2.6
AC Materials	4.7
TOTAL	**13.8**

Table 2



1 Power Optimizer
2:1 configuration

2 Inverter
9kW - 20kW

3 Monitoring
Communication & Control Gateway
Firefighter Gateway

Figure 6

Option 3: SolarEdge

SolarEdge's module level power electronics solution consists of three parts: a power optimizer, an inverter and a monitoring portal (Figure 6). Power optimizers improve energy harvest by placing a Maximum Power Point Tracker at the module level with 15 milliseconds resolution. Power optimizers also condition the power from the modules eliminating losses due to current mismatch and they decrease voltage to increase string length. SolarEdge's power optimizers can improve string length up to 12,750 watts per string–over 100 percent longer than traditional string inverters (Figure 7). Furthermore, the 2:1 power optimizer configuration helps bring cost down on the rooftop by reducing part count by 50 percent. SolarEdge offers 2:1 configuration for both 60 and 72-cell modules.

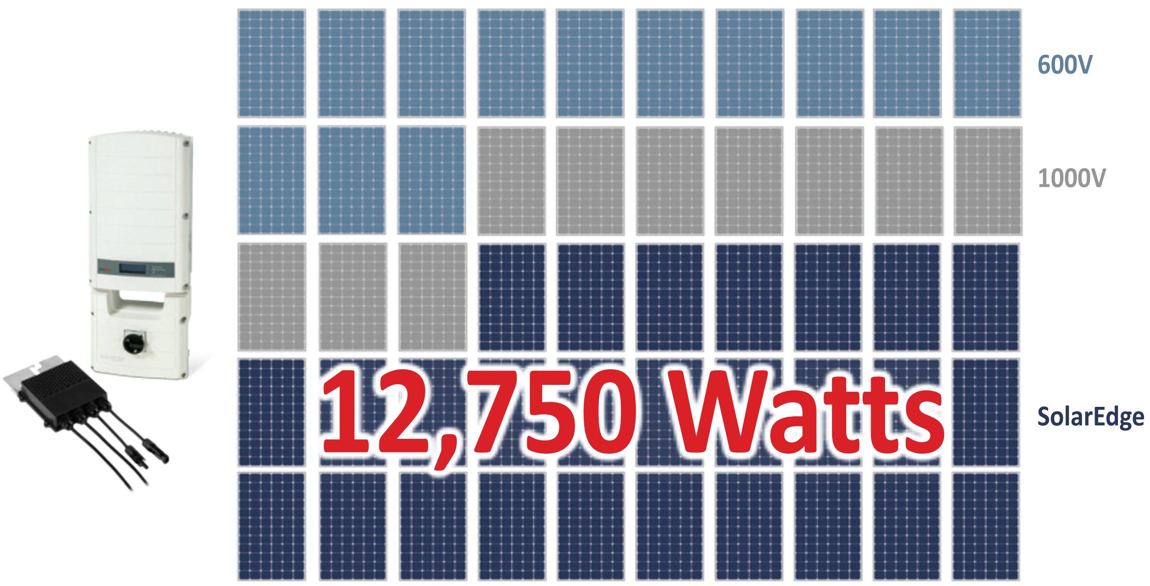
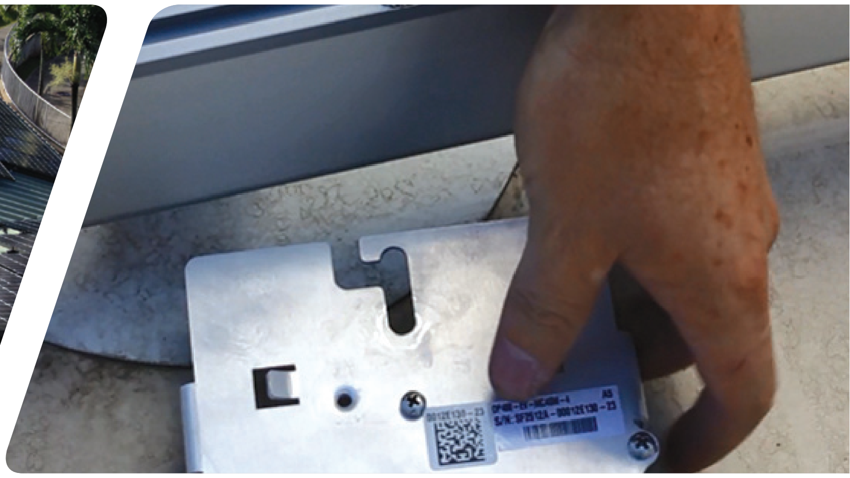


Figure 7

- for 250 watt modules



SolarEdge's inverters operate in an advanced Fixed-Voltage mode and have been designed to work exclusively with power optimizers. The SolarEdge three-phase inverters offer native support for 208Vac and 480Vac grids avoiding additional transformer costs and energy losses. The 20kWac inverter from SolarEdge can be loaded with a 1.25 DC:AC ratio, meaning a 25kWdc rating at full load. By maxing out the dc power on each sting, an installer can fully load the 20kWac inverter with only two strings; there is no need to combine or fuse the DC side of a SolarEdge system. The 20K inverter's weight of less than 80 lbs. enables a wider range of mounting options. Weighing a little more than a 72-cell module, the inverter can be easily installed next to the PV module racks. Similar to the 1000V string inverter design (Option 2), this configuration avoids added costs in regions adopting NEC 2014.

In the analysis, the SolarEdge system design included the maximum number of modules per string. Each module represented 300W at standard test conditions (STC). For the maximum power rating of 12,600 watts, the design utilized 42 modules per string (Figure 8). By running the string 21 modules down and 21 modules back, the 42 module string could reach 140ft on the rooftop (without obstructions). This configuration was used as it fits well within the IFC 2012 regulatory limit of 150 feet. For this design, homerun cables were eliminated as well, leaving only small jumper cables to reach from the PV modules at the row end to the inverter. The design eliminated combiner boxes and fuses using the SE20kW inverters' two native inputs to make all connections.

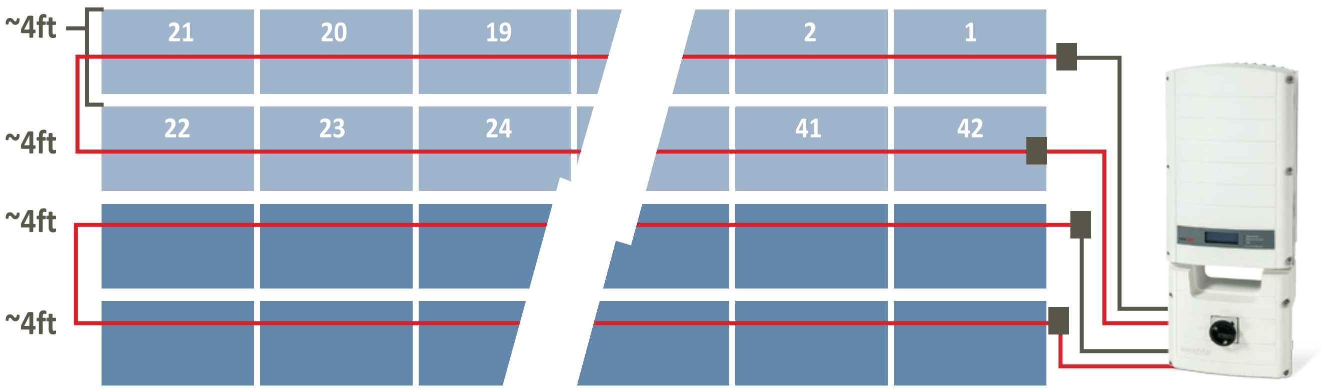


Figure 8

As a result of the elimination of the components, the DC side material and labor nearly reached zero cents per watt. Some minimal labor and components remain for the SolarEdge system. The DC side analysis includes the labor to install all of the optimizers, the labor and materials for jumpers to connect from the optimizers to the inverters and the labor to mount the inverters. On the AC side, costs did increase slightly due to the smaller inverter sizing. The SolarEdge inverter was a 20kWac inverter while the 1000V string inverter was 27.6kWac. The smaller inverter led to more AC connections and a higher overall AC cost of 8c/W. However, the dc side costs were less than 1c/W meaning that in total, the SolarEdge system was less than 9c/W (Table 3).

eBoS	c/W dc
DC Labor	0.3
DC Materials	0.3
AC Labor	3.4
AC Materials	4.9
TOTAL	**8.9**

Table 3

In addition to lower eBoS costs, SolarEdge systems have no requirement to match string module counts. This is a typical limitation of traditional string inverters to keep voltages matched when making parallel connections. SolarEdge power optimizers condition the power and allow different string lengths to be used in parallel. This means, for roofs with obstructions, onsite rework is possible without creating string voltage imbalances. For example, if a vent pipe is missed in the design, an installer can simply remove the single module without any electrical impact to other modules in the array.

Summary of Results

Comparing all three systems side by side, the Solvida study concluded that the SolarEdge system had the lowest eBoS costs (Table 4). The 600V central inverter costs were the highest mainly due to the limitations on string length and the resulting extra expenses for homerun cables, combiner boxes, fuses and recombiner boxes (Figure 9).

The 1000V string inverter and SolarEdge system achieved significant cost savings when compared to the 600V central inverter due to longer string lengths. However, the SolarEdge System was the only system to fully load the inverter on two strings and therefore gained most of the cost advantages through elimination of DC components like combiner boxes and fusing. Sensitivity analysis also showed that in areas with higher labor rates, the SolarEdge cost savings would be higher.

	Central 600 c/W	String 1000 c/W	SolarEdge c/W
DC Labor	6.9	2.3	0.3
DC Materials	6.1	4.2	0.3
AC Labor	1.2	2.6	3.4
AC Materials	3.4	4.7	4.9
Total	**17.6**	**13.8**	**8.9**

Table 4

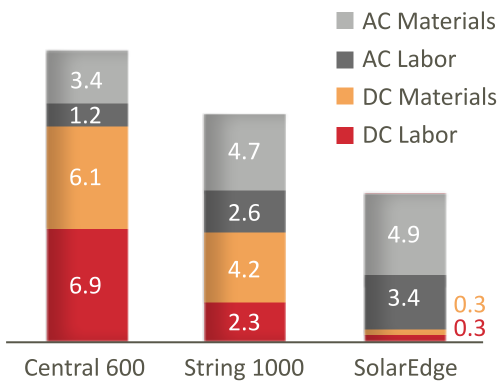


Figure 9

Conclusion: Assessing Total Lifetime Costs

The challenge for the US solar industry is in reducing all costs of a PV installation and not just the eBoS. When comparing the total cost, project developers need to evaluate the eBoS materials and labor, inverter costs and lifetime costs for the inverter. Most inverters today come with a standard 10 year warranty. Thus, to avoid any hidden charges, owners of PV installations should include the cost of a replacement during the 20 year lifetime to accurately forecast the cost of electricity. For the central and string inverters that cost can be modeled in a few different ways: warranty extensions to 25 years, net present value of replacement inverters or service contracts. For this study, we will use the warranty extension price for 25 years as it is the most verifiable number of the three choices.

The SolarEdge system offers the lowest lifetime costs (Figure 10). The SolarEdge inverter includes a standard 12 year warranty while the power optimizer's warranty guarantees 25 years. Thus, the warranty extension is only required for the inverter portion of the SolarEdge installation. As a result, the warranty extension total cost is about one-third the cost of competing warranty extensions.

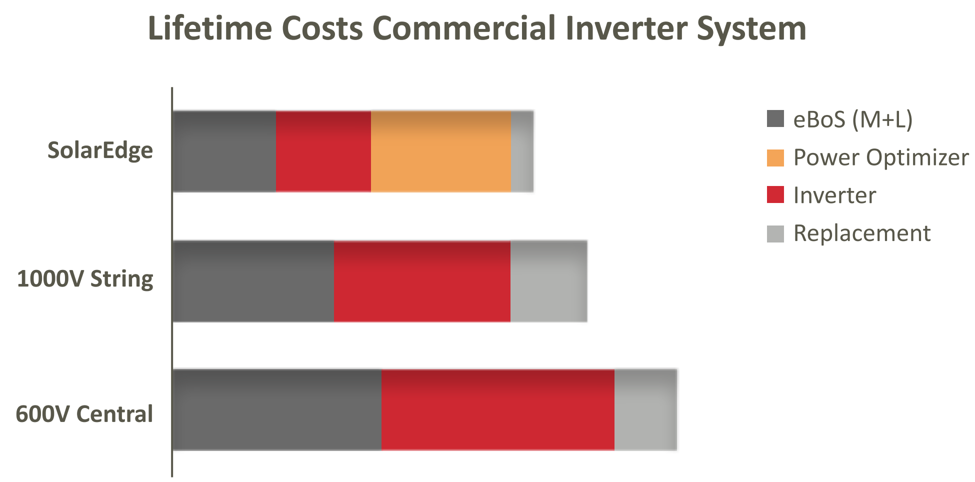


Figure 10

In comparing the material costs, eBoS and life time costs of a central inverter, 1000V string inverter and SolarEdge system the Solvida study demonstrates that the SolarEdge system offers the lowest total cost of electricity. The SolarEdge system is able to achieve the lowest cost through the elimination of eBoS components and the efficient deployment of fixed-voltage inverters and power optimizers. The SolarEdge system demonstrated a lower total cost of eBoS by more than 50 percent compared to 600V central inverters and 35 percent to 1000V string inverters. To learn more about SolarEdge's solutions for commercial solar, contact sales@solaredge.com.