Maximizing Photovoltaic System Cost Effectiveness – The Advantages of Efficiency

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Introduction

The installed cost per Watt of a Photovoltaic (PV) system is the most familiar, and therefore the most frequently used financial metric for PV modules and systems. However, the installed cost per Watt metric provides a very limited tool for comparing different PV products, rather like making a decision on which grade of gasoline to buy based only on the price per gallon but without considering the make of car in which it was to be used. If price per gallon was the only important metric then nobody would buy "mid-grade" or "premium" fuel.

In this paper we discuss the limitations of installed cost per Watt and the importance of understanding "Levelized Cost of Energy" (LCOE) over the system lifetime as a critical metric for evaluating the impact of technology on the lifetime economics of a PV system as that system provides a stream of energy and revenue over its decades of life.

The Light Bulb Analogy – What "Peak Watt" Really Means

Photovoltaic panels and systems are traditionally priced per "peak Watt" of DC electrical power produced under Standard Test Conditions (STC). STC is a world standard defined as the conditions that exist on a cloudless, nearly windless day in the mid-latitudes, at solar noon and with the solar panel facing directly at the sun, and at a temperature of 25^{o}C. These conditions exist in the real world only very rarely and then fleetingly. The standard was originally developed as a means for laboratories around the world to be able to compare test results on a common basis.

This method of pricing is analogous to the traditional pricing of incandescent light bulbs by the Watt, with a bulb that consumes 100 Watts being labeled as a "100 W" bulb and priced higher than a 60 W bulb, for example. Of course the actual measure of performance of a light bulb is not how much energy it **consumes** (higher consumption is actually a negative rather than a positive attribute, since the higher Watt bulb will consume more electricity than the lower Watt bulb and therefore be more expensive to use), but rather how much light it **produces**, how bright it is.

Since the incandescent light bulb has been around for well over a century, most consumers have what feels like in "innate" sense of how the Wattage of a bulb relates to its brightness. We "know" how bright a 100 W incandescent bulb will be versus a 60 W or a 40 W bulb and we can therefore select a bulb that best suits our needs. We have an internally calibrated sense of the **value** of each product.

Bulb manufacturers try to differentiate their own products from those of others by using secondary features such as the lifetime of the bulb or the quality of the light it produces ("Soft White", for example) or the intensity of the light ("Lumens", an objective measure of brightness), but in general, one suspects that most consumers go to the store knowing they want a certain Wattage bulb and their purchase decision after that is mostly based on price because the Wattage is a good proxy for the value they expect to get, at least for the traditional incandescent bulb.

In recent years however, the appearance of newer lighting technologies, the compact fluorescent and the LED-based "bulbs" have complicated this familiar decision making process. These lights use much **less energy to produce the same level of brightness** as an incandescent bulb. The natural way to compare across technologies would be in terms of brightness, but as we discussed above, consumers are long accustomed to comparing Watts. Manufacturers of the newer lights therefore label their products as, for example, "100 W **Equivalent**" so that the consumer has a familiar touch point for their purchase decision. Over time the measure of perceived value is likely to evolve away from Watts (which will have no intuitively useful meaning after the obsolescence of the incandescent bulb) to Lumens, which will allow objective comparisons of value across competing technologies.

In the meantime, it takes a pretty savvy consumer to determine that the "100 W Equivalent" LED "bulb" priced at $24 may actually be a more cost effective **over its useful lifetime** than the 100 W traditional incandescent bulb priced at $3, because the useful lifetime of the LED is much longer and the energy consumption is far lower.

Back to Photovoltaics

Similarly, photovoltaic products are **priced** in units of peak DC Watt at STC, as defined above, even though their **value** lies in the amount of electricity they produce. But, in contrast to the case of the light bulb, **for PV there is no easily internalized qualitative** correspondence between the price and the value. In fact, there is not even an easily **quantifiable** correspondence. Moreover, different PV technologies, deployed in the same place, produce different amounts of electricity relative to their peak Watt rating. The analogy for the light bulb example would be if the incandescent bulb, the fluorescent, the compact fluorescent and the LED had all been introduced at the same time and priced by the Watt, **leaving consumers with no straightforward way to determine the *value* of any given product.**

Complicating this situation further is the fact that differences in performance between PV technologies are much more subtle than for light bulbs, and are also both site-specific and system design specific. This is as if the performance of the same light bulb was dependent on differences in what brand of breaker box was used in the house wiring, or on how far the house was from the nearest power plant.

Because of this, comparisons between different PV technologies in terms of power **yield**, while easy enough to do for existing systems, **are difficult do well**. That is, it is relatively easy to obtain data, but very complicated to ensure that the data is meaningfully interpretable. As a result, there is a great deal of contradictory information in both technical and marketing literature about whether one technology or another is superior under, for example: low light conditions; or high temperature conditions; or diffuse light conditions, to name the three most common areas of comparison.

LCOE – A Value Metric

Obviously, price per peak Watt is an important metric as this determines the overall **cost** of a project (PV modules and "balance of system" (BOS) gear such as inverters and racking make up the bulk of the "install" costs with these components costing anywhere from 50% to 70% of the total initial cost).

But considering only this upfront or "Installed cost per watt" can be very misleading, and financially dangerous! Price per peak Watt is a **cost** metric, but is a poor measure of **value**.

In contrast LCOE is perhaps the most important measure of the **actual** value of a system, based on its **true power output in its installed configuration and over its useful lifetime**. As in the light bulb analogy, a high efficiency PV panel may cost more than a lower efficiency one, but be more cost effective over time because the higher efficiency not only allows savings on BOS costs but also delivers more energy over the system lifetime.

Importantly, the units of LCOE are dollars per kilowatt hour ($/kWh), **a unit of value to which everyone who pays an electric utility bill each month can relate.** Rating a PV system in this way immediately allows intuitive comparisons not only between different PV technologies, but also allows direct comparison with conventional sources of electricity.

Suniva's Value Proposition

Suniva's cost effective, high efficiency cell technology is at the core of our high powered Optimus® modules, which produce **more power per unit area** than other brands at a competitive cost. High-powered modules are the key to maximizing the total power produced in areas with constrained space, such as rooftops, parking canopies, and in any situation where producing more power over the lifetime of the system is important. In any setting, producing more power in a given area, or requiring fewer module strings to produce a given power output (therefore reducing other system components, labor, space and maintenance costs over time) is the basis for achieving both a competitive initial system cost and a lower "levelized cost of energy" (LCOE) over the life of a system.

In a sense, the higher efficiency leverages value twice: once at the front end of the project cost, and then constantly over time as the system delivers energy.

Advantage 1: Better System Install Costs

"Install" costs (direct capital cost for a PV system) represent an expense for a specific piece of equipment or service that applies in year zero of the cash flow. These include the following:

1. PV Modules
2. Inverters
3. Balance of system (racking, combiner boxes, wiring, piping, switches
   Installation labor, Installer margin and overhead, contingency)

Initial costs that are not component related may include:

1. Permitting and environmental studies
2. Engineering
3. Grid interconnection
4. Land (or roof space)
5. Land preparation
6. Sales tax

The cost metric (cost per peak Watt) and performance at STC metric together impact the overall initial cost of the system.

For every system BOS costs include the costs of the racking, harnesses, combiner boxes, installation labor, and installer margin and overhead (it does not include the cost of the panels, inverters, land, or operations and maintenance). BOS costs generally scale by system area or by discrete unit items. The quantity of gear is directly impacted by the number of modules, strings, and cumulative area taken up by the entire system. **Using high efficiency modules to produce a given amount of power translates into fewer racks, wiring, labor, space and eventually, maintenance costs.**

Higher efficiency modules at a cost-effective price make sense. A key advantage is the smaller footprint. More power in less area translates into a lower number of panels required to meet the same nameplate power production. This also results in a lower number of strings and that also translates into less balance of system gear required (mounting hardware/racks, harnesses and wiring, conduit channels, combiner boxes, and DC-disconnect switches). Labor costs also scale up or down based on the area or total amount of discrete gear required. There is less hardware to maintain over the entire life of the system. The impact is cumulative.

Advantage 2: Lower LCOE

Using Suniva's high power modules brings another advantage for LCOE. Cost-effective high efficiency monocrystalline panels can also yield a ***larger energy production***. Two key factors contribute to this in the case of Suniva Optimus panels:

[1] Suniva Optimus 2XX series panels have less than a 1% mismatch from nameplate. Most panels typically have a 2% or even a 3% mismatch. Suniva uses the ***highest quality*** materials in its modules to ensure a long service life and high energy output over time. Suniva conducts on-going component and materials testing in their module labs to incorporate the latest advances after proving reliability. Witness our 25 year linear power warranty.

[2] Higher efficiency generally also means better high temperature performance. A lower temperature coefficient results in less sensitivity to temperature changes and a more steady energy yield over its lifetime.

The Bottom Line

Before making a purchase decision involving PV modules, it is critical to consider both the system-level cost and the LCOE over time. Both are site-specific and technology-specific, with LCOE in particular requiring sophisitcated programs to determine energy output and financial performance. Suniva can provide validated models for these metrics. We would be happy to demonstrate the **double-leverage value** of our high-efficiency products for your next system.