Managing Expectations with Solar Photovoltaic (PV) Technology

When many new or developing technologies are brought to the marketplace, there is often a great deal of excitement surrounding the possibilities the technologies present – but sometimes the detailed knowledge related to the technology is slow to reach a wider audience. This could be said for the expanding solar PV market. This article will attempt to highlight some, but certainly not all, of the common and most relevant concepts surrounding solar PV technology that can inform further research and discussion by potential PV consumers. Always ask lots of questions of potential solar PV contractors to be sure you understand the issues well enough to make an informed consumer decision.

The prices for solar PV systems seem to be decreasing all the time; even so, PV technology is generally an expensive method of energy production. There can be many reasons additional to, or separate from, financial considerations that people may choose to install solar PV, but it's important to be clear about what those reasons are, even to the point of quantifying them where possible. This helps a potential consumer consider their investment with all the facts, manage their expectations related to what their solar PV project can do for them, and ensure they are satisfied with the results of their investment.

Common Types of Solar PV Equipment

The most common type of equipment for generating electricity from solar PV is still the individual large box-like units with the blue or black solar cells on the surface (properly referred to as "modules", more commonly referred to as "panels") that come to mind when thinking of PV. But due to manufacturing advances, specifically improvements in thin film technology, solar PV can now be integrated into many common building materials such as solar shingles or building facades. These materials can often be somewhat lower cost, although at the same time they tend to have a lower efficiency and lower expected life. Where the space available for a solar PV installation is not limited, these types of products can be a viable choice of materials; where space is more limited, usually higher efficiency products are desired. While there are continual reports of solar PV efficiency breakthrough at R&D lab scale, the actual commercial-ready module efficiency tends to range from 9% to 22% efficiency, with thin film products commonly in the range of 4 to 8% efficiency.

Solar PV modules produce direct current (DC) electricity, so systems require an electronic component – an inverter – to convert the electricity from the direct current output to the alternating current (AC) used by the majority of appliances and as supplied by the electricity grid. Large PV systems with multiple modules/panels can be set up using a line (also called „string") inverter where several panels are connected together and feed into the string inverter. If any of these individual panels experience production problems (such as with the equipment, or due to temporary shading), the output of the entire string can be affected. A newer product available on the market is a micro-inverter. A separate micro-inverter would be installed on each individual solar panel so that the DC output of each panel is converted to AC right at the panel output, and is transmitted as AC back into the main panel connection (other intermediate components are required in solar PV systems that won't be discussed). An advantage of a micro-inverter setup is that problems with an individual panel do not impact the remaining panels in the group.

Factors Affecting Energy Outputs

Solar panels have a Rated Output (usually stated as P_{max}, given in Watts (W)) based on their performance under an industry-standard test procedure, called Standard Test Conditions (STC). STC are fixed conditions used by industry for testing so that the output between panels can be compared. Multiple criteria are set in the STC, but two important ones are the Temperature, and the concept of a Peak Sun Hour. The main thing to keep in mind with temperature is that the resistance of electrical components gets higher as the temperature gets higher, and with higher resistance the performance is decreased. So on a very bright sunny day in the summer, when overall the electricity production has increased due to the strong sunlight intensity, it hasn't increased as much as it could have if the panel temperature had not increased at the same time.

A Peak Sun Hour is defined as having a solar intensity equivalent to 1000 Watts per m2 for that hour. The number of actual daylight hours in a given day is not the same as the number of Peak Sun Hours in that day. The Peak Sun Hours are always less because the intensity of the sunlight in the morning and evening hours is less than the Peak Sun Hour standard of 1000 W/m2. If you know the Peak Sun Hours for a location for a given day, you can estimate the system output by multiplying the Rated System Size (in Watts or kiloWatts) times the number of Peak Sun Hours (in Hours) to calculate the energy output in Watt-hours or kiloWatt-hours. In some Canadian locations in the winter, the Peak Sun Hours can be as low as 1 to 2 Peak Sun Hours per day.

The intensity of solar energy hitting the surface of a solar PV material is also affected by the angle at which the solar energy hits. The maximum amount of energy is received on the panel surface when the angle of incidence is 90 degrees (perpendicular) to the surface. This makes the concept of tilt angle – the angle at which the solar panels are mounted – a very important consideration to maximize the energy output of a system. The difficulty is that the angle of the sun changes constantly, both throughout an individual day and also over the course of a year. It was for this reason that tracking systems have been developed that can track the sun on one or two axis (east to west and/or higher and lower tilts). It is unclear whether these tracking devices yield a net benefit for Canadian systems, as most initial reports appear to indicate that the additional cost (and maintenance required for the moving parts) isn't justified in a large enough system output improvement. An experienced Installer should be able to do a cost-benefit comparison on the option of using a tracking system to help you decide if that is a technology you want to pursue in your system.

A slightly simpler method of following the sun over the course of a year (but not following the daily changes) is to use a rack system that allows manual adjustment of the tilt angle of the panels, which would typically be done not more than 2 to 4 times a year. Experience has shown that the thrill of capturing more solar energy by manually adjusting the tilt angle, quickly wears off after the first year, and choosing a fixed tilt angle installation for year-round is still the most common method. For a year-round average, regardless of geographical location, it is generally accepted that the optimum tilt angle should be equal to the angle of latitude of that particular Managing location, or within 15 to 20 degrees of latitude. Other factors may influence the decision to use a fixed mounting angle that is not optimized. Maximizing the system performance with these types of details is most critical with off-grid systems, and usually less critical with grid-connected systems. Installers should be able to provide a cost-benefit comparison for various installation tilt angles for specific applications.

A website that can provide an energy production comparison for various tilt angles at a location, can be found at: http://pvwatts.nrel.gov/index.php

Factors Affecting Solar Resource

While one great thing about solar PV technology is that everyone has access to the sun, it is true that the solar resource does vary by location. The actual solar resource can have a tremendous impact on the energy produced by a solar PV system. Latitude is a significant factor affecting the solar resource. The federal government has an online solar map that can estimate the solar PV potential for your location based on the nearest town.

Go to: https://glfc.cfsnet.nfis.org/mapserver/pv/search.php?lang=e&prov=alta

i. Use the alphabetical index to search by the closest town name
ii. Of the three available charts, use the first one “PV potential (kWh/kW)”
iii. On this chart, the “tilt=latitude” column may be the most appropriate estimate

As an example, the chart for Manning, Alberta indicates a solar PV potential of approximately 1179 kWh/kW per year for a south-facing installation where the tilt angle of the panels is equal to the angle of latitude of the location (approximately 56.9 degrees N). The chart for Bow Island, AB shows a solar PV potential of approximately 1362 kWh/kW installed. For comparison, although it‟s a city we all associate with pleasant weather, the chart for Vancouver, BC shows a solar PV potential of approximately 1009 kWh/kW installed per year.

Be aware that a location may experience temporary or periodic resource issues due to shading from cloud cover (the issue for Vancouver) or by physical obstructions (nearby buildings or trees, or adjacent solar panels in a system), and that any physical / electrical system will have internal losses.

Contact

Please contact the GF2 Solar PV Program office staff with any additional questions you may have.

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