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Shedding Light on Solar Power

By John Johnson

ADMITTEDLY, I am not an average consumer. Working in the electronics industry for almost 30 years contaminates one's view of technology. "Technicians" tend to be early adopters (I was one of those who was on a waiting list to buy a Toyota Prius). However, I view the hype that often accompanies innovation with a degree of skepticism. Something has to be relatively cool, have some significant utility and be reasonably reliable to be attention getting. So, why not look at solar energy in this issue since it exhibits all of these attributes? What would be involved in taking a small structure like a pool house or a shed off the power grid using solar energy?

According to the March 2009 issue of Scientific American, solar power is "commercial but competitive in grid

applications only when demanded by quota or heavily subsidized." I decided to perform a 'back of the napkin' look at the problem to see how far the gap is between this characterization and what can be purchased and installed in a residential application.

SETTING THE STAGE

Assume we have a shed that is 10' X 12' with a couple of windows and a door. It is well insulated, air conditioned and includes a few outlets and an overhead lighting fixture. To simplify the problem, I will examine the air conditioning by itself. How do we take an air conditioner off the grid and use solar power to operate the unit?

THE AIR CONDITIONER

How big does the air conditioner need

to be? The value of a term called "cooling load" must be determined. A laundry list of factors can influence cooling load including climate, building construction, orientation and insulation. Fortunately, there are resources online to help and I took advantage of them (see resources list).

The cooling load for this application is just under 5,000 BTU (1) /hour; however, without insulation, the cooling load soars to 12,500 BTU/hour. Taking into account the local climate and building characteristics, the estimated operating time of the air conditioner is 1,374 hours/year.

With respect to the efficiency of the air conditioner, two parameters are important. SEER (Seasonal Energy Efficiency Ratio) represents the average efficiency of the air conditioning unit.

EER (Energy Efficiency Ratio) represents the efficiency during peak usage times (when you run the thing at full blast). Because the cost of a solar array increases with the power it is capable of delivering, coupled with the inevitability that the A/C must operate at full blast at certain times, a high EER is highly desirable to minimize the cost of the solar array. Bear in mind that the more efficient the A/C unit is, the more expensive the initial equipment cost will be. Since the objective is to save energy, we will spend the money for a 10.7 EER unit; making our peak power usage 475 W (Watts).

Solar arrays have come a long way and the industry continues to develop solutions that are more efficient and less expensive than earlier generations.

To calculate the peak power usage, divide the cooling load by the EER. A reasonable estimate for electricity cost in Frisco is about \$.13/kWh. What does this mean? You pay \$.13 to the power company when the power you use (expressed as Watts) multiplied by the time that you use the power (hours) equals 1000. If you burn a 100 Watt light bulb for 10 hours, you will need to write a check to the power company for \$.13. Based on this rate, our air conditioner would cost about \$.06/hour to operate.

A/C UNPLUGGED

While sunlight is certainly free, here are a few of the “inconvenient truths” regarding solar installations: they do not generate power after sunset (duh), they are somewhat expensive and there is a bunch of other stuff you need to install alongside the solar array to duplicate the operability that a

grid connection affords. Furthermore, shade, clouds, dust, bird droppings and anything else that reduces the amount of sunlight that hits the panel can greatly influence energy conversion (e.g., blocking 1/36th of an array will degrade power output by as much as 50%). Let’s not talk about the call to the insurance adjuster when one of our infamous hailstorms has damaged your solar panels.

THE DEVIL’S IN THE DETAILS

Conventional air conditioners operate from the power grid on alternating current (AC). Solar arrays deliver direct current (DC), meaning that additional equipment is required to route the power supplied by the solar panels to the air conditioning unit. If a conventional air conditioner is used, a device called an inverter to convert DC to AC must be included. Unfortunately, inverters introduce inefficiency because not all of the power delivered by the array can be converted into alternating current.

Air conditioners that operate directly from a DC source are available, developed specifically for solar powered applications. The array must have the capacity to convert energy to operate the air conditioner and charge the batteries at the same time. Energy must be stored in batteries for use when the solar array cannot provide the required ‘umpf’ to run the system during periods of darkness or clouds.

Solar arrays have come a long way and the industry continues to develop solutions that are more efficient and less expensive than earlier generations. The current benchmark for solar array cost (sans installation) is about \$1 / Watt of peak output capacity (cost for solar panels only); with installed cost averaging about \$9 / peak watt, including the inverter.

What factors would cause our system to operate at ‘non-peak’ capacity? Assuming that none of the aforementioned bird droppings, clouds, dust, etc, are present (bad assumption), an index called the Direct Normal Irradiance (DNI) comes into play. This is a measure of the ‘sunny-ness’ of the area at which the array is installed. For Frisco, the value is around 5 (very

Shopping List

ITEM	APPROX. COST.
Solar Arrays, installed with inverter:	\$5,000
Battery Subsystem (including charger):	\$1,700
Air Conditioner, 5000 BTU EER 10.7:	\$ 300
Misc (permits, etc)	\$1,000
Total:	\$8,000

Resources

A/C Capacity Calculator: www.consumerreports.org/cro/appliances/heating-cooling-and-air/air-conditioners/sizing-worksheet/

Low cost solar arrays: www.firstsolar.com

Power utility shopping mall: www.powertochoose.org/

Regional alternative energy use incentive database: www.dsireusa.org/

Solar powered A/C for residential applications: www.solcool.net/

Solar Array Sizing Calculator: www.sunsglobal.com/calculator.html

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good). So if we purchase a 100 W solar panel, we can expect about 500 Wh (Watt-hours) of capacity in a day's time assuming a south facing stationary installation. For our system, we must produce 650 kWh per year to operate the air conditioner based on all of the stated assumptions. This will require a 500 W solar array (4 X 125 W panels). A typical 125W panel measures 60" X 27"; therefore four panels occupy about the same area as our south-facing roof face.

CLOSING THOUGHTS

The useful service life of the solar panels is approximately 20 years. They require regular cleaning and inspection. The service life of the batteries is something less than three years; and they require regular maintenance and inspection as well. Those enamored by solar technology are often motivated by the altruistic notion that they are doing what it takes to preserve the environment. However, the fact is that the production of the arrays and the production and disposal of the batteries constitute an overlooked environmental concern (we won't talk about the batteries on the Prius). A cost analysis of both approaches does not seem to provide even a scant justification for solar power. However, as a Prius owner, I sometimes don't make decisions entirely with a spreadsheet. There are subsidies and incentives available for those installing solar power; however, many of them are for commercial installations. Perhaps a better route for Frisco residents is to implement relatively inexpensive and traditional energy conservation methods (e.g. the cooling load increased by 2 ½ times without insulation).

Finally, as a reminder, this is only a back of a napkin analysis. Without a doubt, information is available to both support and disprove these claims.

(1) British Thermal Unit. The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit at sea level (definite cocktail party discussion material).

John Johnson is a local electrical engineer specializing in the application of semiconductor and electronics technologies.

It Doesn't Take Green to Be Green

PROMOTING A GREEN LIFESTYLE may be a goal of any thriving metropolis such as Frisco, but living green doesn't have to break the bank. Whether you are interested in new construction, remodeling or adding on, there are ways to live green without spending a lot of green.

In new construction, for zero additional cost, consider the position of your house on the property. Strategic orientation can have the most impact of any green or sustainable action or initiative. Protection from – or inclusion of – sun exposure and prevailing winds can dramatically decrease the energy used to maintain ideal temperatures inside a new home. Integrate cool (light colored) roofing materials, attic vents and a radiant barrier in a renovation and reduce the thermal gain by over 70 degrees. The result is lower electric bills because the AC doesn't have to work as hard to get the heat out of the house. Repair leaks and install low-flow toilets to reduce water usage. Try using CFL bulbs, Energy Star and lighting timers to reduce your use of electricity. Extend green concepts out of doors through xeriscaping (use of drought resistant materials) or Free-cycling (giving and receiving of items at no cost). Relocating landscape timbers from one person's garden to another gives the landfill and your wallet a break.

When considering building a new home or renovating an existing one, a design professional can assist you in completing a cost-benefit analysis to help you make sure that you're helping the environment in a fiscally responsible way and that your investment is paying for itself in a reasonable amount of time.

Clara Carlisle is an architect at 708 Studios, a full-service architecture firm based in Frisco.

Go Green! – With Frisco's own Green Team

FRISCO PUBLIC LIBRARY will host Go Green! -- with Frisco's own Green Team on April 16! For everyone interested in the personal and community benefits of green living, a panel of experts will discuss how to save money with energy-smart home improvements, conserve water, evaluate residential irrigation systems and recycle. There will also be information about Frisco's Community Garden.

The Green Team leaders will show environmentally-friendly ways to improve quality of life while contributing to the city's commitment to become a green community. Frisco's Green Team includes Pippa Couvillion, Environmental Services Manager; Ryan Middleton, Comprehensive and Environmental Planner; Jeremy Starrit, Environmental Education Coordinator and Melody Emadiazar, Water Education Coordinator.

Bring your questions and comments; the meeting will include an open-forum opportunity for you to get answers and learn how you and your family can benefit by joining the Frisco Green Team. The panel members are eager to share their expertise with the community.

Thursday, April 16, at 7 p.m. in the McCallum Room on the 4th floor.