Energy 108 – Solar Cells II

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Perhaps you have wanted to do your part to promote the end of fossil fuels and thought about having a photo-voltaic (PV) system installed on your new home. Frankly, that is a dream mostly created in you by very devious, but typical, Ruling Class politicians who are always out there dangling a carrot, if you will only reelect them so they can raise taxes to pay for their pet project. This is not meant to insult or demean those of you who are truly interested in helping keep the environment 'clean', but you must not take too seriously the opinions of Ruling Class politicians as to how to do that or how effective our tax dollars can be in the process. Remember, Mother Nature has her laws and rules that must be obeyed in her house and she depends on the scientists, engineers, and technicians to objectively help educate the politicians to promote and enforce those laws and rules. Although, it has been said that the CO2 released by the recent eruptions of the Icelandic volcano has been more than that released by all the automobiles ever manufactured . . . so her act is not that clean either.

Back to Solar Cells. I thought it might be enlightening to work out a preliminary quote on a residential PV system. Much of this is based on the credibility of a website: http://www.solarbuzz.com. It follows the whole PV industry and lists current prices and trends. Other references that have helped are:

Direct Energy Conversion, by Stanley Angrist, 1965 . . . and *The Passive Solar Energy Book*, by Edward Mazria, 1979.

These books (Angrist, and Mazria) may seem dated but they represent the core of this subject and indicate that a lot of technical types have been interested in renewables for a long time. A couple of 'Commenters' took me to task on my last episode where I wrote: "Photovoltaics have been around for well over a hundred years." In response to them, I can only quote from the Angrist book: "Edmond Becquerel in 1839 noted that a voltage was developed when light was directed onto one of the electrodes in an electrolyte solution. The effect was first observed in a solid in 1877, by W. G. Adams and R. E. Day, who conducted experiments with selenium. Other early workers with solids included Schottky, Lange, and Grondahl, who did pioneering work in producing photovoltaic cells with selenium and cuprous oxide."

With regard to a domestic PV system, we must first look at some realistic facts. To meet most local building codes, you are usually required to have an electrical system capable of providing about 23 KW (100 A, @ 230 V.) of power in a medium sized residential dwelling. Let's assume the worst case scenario to start with. You are building in a remote area where no Grid power is available, so you want to buy a PV system that will have that average capacity for at least a majority of the 24 hours in a day. Checking the solar energy tables for Fresno, CA (37 deg. N lat.), which may be near where you want to build, you would find the average daily solar energy receipt for the month of December (lowest month) is about 800 Btu/day-sq. ft. or about 0.01 KW/sq. ft. So, using that number and the Code requirement of 23 KW, we must decide how many hours of the day that amount of power may be required. Suppose we use the 'Two Rate' scale many power providers use, i.e. a higher rate is charged during the high demand hours ('On Peak') than the rate charged during 'Off Peak' hours. I happen to be on that plan and during the winter, the high rate ($0.150/KWH) is in force 13 hours a day and the low rate ($0.062/KWH) for 11 hours a day (there is a different schedule for summer). We will assume the client's proposed home is similar to my single story house which is of what's known as a 'Passive Solar' design, meaning that at this Latitude, the house is placed so the south side is approximately on a ENE – WSW line; the south roof eave overhangs are about 18 inches; and the south wall is approximately 40% glass. I am required by building code to have auxiliary heating, which in this case are individual 1500 watt electric baseboard units in each room.

I made an attempt to find any local codes that pertain to the subject of 'active' solar heated homes, but was unsuccessful . . . so, I'll just try a 'S.W.A.G'.

Let's assume I may be consuming electric power at about 2/3 my max capacity during peak load hours (about 13 hours per day) and about 1/3 max capacity during off peak hours (about 11 hours per day). So, even though my house wiring design requirement is 23 KW, I am not using that 24 hours a day. So I am assuming my proposed PV system may only need to supply a maximum of about 15 KW (2/3 of 23 KW) as a power requirement. The energy requirement would be about 15 KW for 13 hours plus 8 KW for 11 hours or 283 KW-hr per day. In actual fact, my average daily electrical energy usage for last December was only about 100 KW-hr.. So assume the average of about 190 KW-hr/day (ave. of 283 and 100) as being the energy requirement. Assuming I have about the same solar energy level available as Fresno, doing the division of electrical energy required per day by the solar energy available per day per square foot gives: about 800 sq ft as the amount of sunlight capture area required to produce the amount of energy required in electrical form, if the solar to electrical conversion were 100% efficient . . . but 100% solar conversion PVs are accepted as an impossibility, as discussed in the last episode, 'ENERGY 107'.

So, assuming this system is to be installed within the next 5 years, the best that can be expected is about 15% conversion, so the PV area required would be 800/0.15, or 5300 sq ft. Realize that area may supply 800 KW-hr, but only during sun lit hours, however power must be supplied after the sun goes down, so batteries must be used. But what is going to charge the batteries enough to last through the evening

hours? By doubling the PV area to 10600 sq ft will provide that energy for storage . . . and an additional 5000 sq ft PV area and battery storage capacity should be added to provide for cloudy days.

So, our simple PV generation system has grown a bit . . . from 800 sq ft. to about 15600 sq ft (that's a 125 ft by 125 ft structure or 1/3 acre) and a bank of batteries for storage of about 1200 KW-hr. There is still a major consideration and that is the nature of the electrical power supplied by PVs and stored in the batteries. It is 'direct current' (DC), however except for things like incandescent light bulbs (which the Ruling Class says in 2012, they will be illegal to sell in USA), toaster ovens, heating pads, and a few items with 'AC-DC Universal' motors, our houses run on 'alternating current' (AC). This was decided about 100 years ago when George AC Westinghouse won the war with Thomas DC Edison. This includes: appliances, air conditioners, fans, TVs, radios, portable device chargers, fluorescent lights, etc., all operate only on AC . . . and yes it includes those Compact Fluorescent Lamps (CFLs). So it is necessary to convert the DC power coming from the PVs into AC power using an 'inverter'. All of these components must be linked together and controlled by a rather sophisticated Control Assembly.

So, what is the bottom line? It has been many years since I have prepared an engineering price quote, but I will take a shot at giving some idea about how much it might cost to power that sample home with Solar Cells and technology as outlined above, for an extended near future . . . as politicos search for the perfect compound or alloy that gives 100% efficiency in PV conversion.

Pricing on PVs is usually based on maximum wattage or power carrying ability, which is a rate of their input solar radiation energy spectrum conversion into a 'direct' current and voltage (DC). They may be put in series to raise the DC voltage output or in parallel to raise the current carrying ability of the circuit. Typical prices vary from: $4/watt to $8/watt depending on output voltage, current, physical form, or semi-conductor material.
This type of pricing is also true of the 'Inverters' which converts the PV's DC output into a commonly used 'alternating' current and voltage (AC), usually 110 Volts RMS in amplitude, varying in a sinusoidal fashion at a frequency of 60 Hertz (US Standard). They can be of a "Static" form which consists of discrete or integrated circuit components . . . or of "Dynamic" form which is usually a constant speed rotary DC motor powered by the PV/battery output and driving a rotary AC generator. Typical pricing is about $100/KW.

Batteries are used to store the PV's DC output for later use. They can also be used as a filter to smooth and stabilize the PV output. Commonly (for economics) they are regular 6, 12, or 24 volt DC lead/acid automobile, truck, marine, or aircraft batteries and can be arranged in series, for higher PV output voltages . . . or in parallel, for more energy storage. They usually are rated by "Amp-Hr" capacity (Energy at a constant voltage). Typical pricing is about $210/KWhr.

So what would a cost estimate look like for such a system?

Solar Cells: 35000 watts (15600 sq ft) @ $8/watt $ 280,000

Batteries: 1200 KWhr @ $210/KWhr 252,000
Inverters: 35 KW @ $100/KW 3,500
Control Center: 35 KW @ $1000/KW 35,000
Installation & Checkout:
Engineering: 1000 hr. @ $60/hr. 60,000
Technical: 3000 hr. @ $20/hr. 60,000 TOTAL $ 690,500

Looking at my annual use of electricity, last year it was 20,660 KWhr. Assuming that usage for 25 years (expected life of PV system) at that consumption level gives 516500 KWhr total, from a system which would cost $690,500 or $1.34/KWhr (not including any maintenance or repair). Presently I am paying about $0.12/KWhr (including service charges and taxes) to my provider.

Question: Would you be willing to pay ten times more for your electricity even though you knew it did virtually nothing to improve the environment? I would not . . . and I am not!

I know . . . what about tax credits? Oh yes, that is the Socialist way. Although I would not have a PV system, I would be helping to pay for a part of everyone's costs who do, with the Washington Politburo of the Ruling Class setting the amount . . . as it is now for wind generated power. Have you ever thought about the per unit release of 'unavailable' thermal energy and toxic materials into the environment that are required to mass produce these 'Green' items?

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