Humboldt Energy Task Force
Residential Solar Photovoltaic
Program Recommendations

Prepared by

The Schatz Energy Research Center
August, 2001

Executive Summary: Rooftop PV Project Recommendations

The Schatz Energy Research Center (SERC) at Humboldt State University was asked by the Humboldt Energy Task Force (HETF) to prepare technical recommendations for creating a residential solar photovoltaic (PV) program. In its first report to HETF, SERC provided general technical and economic analysis of rooftop PV and compared its costs and benefits to those of rooftop solar thermal systems and home energy efficiency improvements. This second report provides more specific recommendations, including comparison of specific PV products.

SERC has selected three combinations of PV components to recommend as standardized systems for the HETF's proposed residential solar program. Any of the three systems would be satisfactory. A decision on which of the systems HETF chooses for a bulk purchase program could be based on equipment availability, cost, and/or aesthetics.

We recommend the following systems for a rooftop PV project in Humboldt County:

1. ASE Americas PV modules (ASE-300-DGF/17-300)
Inverter: Advanced Energy Systems GC-1000
Mounting: Roof Jacks (Schott Applied Power)

2. BP Solar PV modules (BP275)
Inverter: Advanced Energy Systems GC-1000
Mounting Structure: Unirac

3. Siemens PV modules (SP75)
Inverter: Advanced Energy Systems GC-1000
Mounting Structure: Unirac

Please see Table 1 for more detail on each of our recommendations. We have designed PV systems with three different sets of components, since PV panels are currently in short supply and may not be available. The net cost of all of the systems we recommend is estimated to be between $4,600 and $6,200, assuming that the maximum CEC rebate of $4.50/W is available. At 100% financing of the systems with an 8.75% home equity loan, participants will be paying $20 to $35 more per month for their green electricity. (Clearly the out-of-pocket cost of the system can be reduced if residents pay cash.) If the funds need to be borrowed, we suggest the resident obtain a home equity loan, as interest rates may be more competitive than those for unsecured loans, and the interest paid will be deductible for those who itemize on their tax returns.

In our search for the optimal PV system for Humboldt County rooftops, we contacted the Sacramento Municipal Utility District (SMUD). The people in charge of their PV Pioneer Program are willing to make available the equipment that SMUD is installing at extremely low prices. We do not, however, recommend this system, for a variety of reasons. Durability of the system is undetermined, and although the component cost is less than that of the other systems, high installation costs may offset most of these savings. Please see further explanation of these points under the section "Partnering with SMUD."

We recommend that Humboldt County authorities begin with a very simple program. Such a program might purchase equipment in bulk, provide the drawings for one standard design, make available a list of possible contractors who can install the equipment, and streamline the permitting process. Interconnection agreements, financing, changes in design, and other aspects of PV installation would be up to the resident, although this program could provide guidance in these areas. Some of the material we provide in this report makes this possible.

A course of action for local authorities might include: performing an informal market survey to determine the size of the program, deciding what human/financial resources to commit to the

program, designing the program, advertising to residents, obtaining a list of qualified and interested participants (including signed letters of intent), notifying participants to reserve their CEC buydown (see attached reservation form), negotiating prices with manufacturers, placing an order for equipment, receiving and distributing the equipment, and sending out a follow-up survey to participants.

System Components

PV Modules
PV modules are currently in high demand, and some varieties may not be available. However, since the quality of all of the modules listed is high, any of the three systems shown above would be satisfactory. All of the manufacturers mentioned here are reputable, offer a 20 or 25-year warranty, and make a product that has been proven over the years. While our first choices were ASE Americas, BP Solar, and Siemens, three others are also reputable: Kyocera, Solarex, and Astropower.

The ASE prices are the initial quotes directly from the manufacturer. All other prices shown on the system spreadsheet are the lowest prices found on the Internet. Lower prices are probably available: we will not know how much lower until we approach each manufacturer with an order of, say, 100 systems in hand. We suggest negotiating with the manufacturers directly when 100 residents have submitted a letter of intent to purchase a system. (See the appendix for a sample letter of intent and questionnaire used by SMUD.)

A decision on which of the above systems to use may be based on: 1) availability of components, 2) cost per watt of components, 3) ease and low cost of installation, and 4) appearance of the PV modules (if aesthetics are important). SERC has contacts at ASE Americas and BP Solar, and is willing to contact other PV manufacturers such as Astropower and Siemens in order to obtain low prices for components.

We have assumed that most people in Humboldt County who wish to install PVs will have an available, south-facing, unshaded roof space of 100 square feet. This is enough area for approximately 1kW of modules. All of the systems recommended will produce about 1kW of AC output.

Inverters
Prices for inverters are directly from the manufacturer, Advanced Energy Inc. (AEI). The catalog price of their 1000W inverter (called the GC-1000) is $1,700. AEI will discount the price to $1090 for a minimum volume of 100.

Another option for inverters exists. A German manufacturer called SMA makes an 1100W inverter whose volume price is $660. However, this inverter is not yet UL-approved or on the CEC's list of equipment eligible for rebates. UL and CEC certifications are scheduled to occur by October 2001. Another inverter made by SMA that is for 2500W systems is already on the CEC list, has so far shown excellent performance, and has been heartily recommended by those who install systems. This family of inverters is called Sunny Boy. Using the Sunny Boy 1100 instead of the GC-1000 could result in a reduction of system costs of about $500. However, the use of the Sunny Boy 1100 would be, at least in the beginning, experimental. In addition, this inverter requires voltages between 150 and 300Vdc (as opposed to the 52-92Vdc of the GC-

1000). The higher voltage required by the Sunny Boy may be more hazardous for installers and equipment servicers.

Balance of System Costs
We have assumed a constant installation price for purposes of simplicity. This will not be true in real life—in fact, installation costs are highly variable depending on the site, the module type, and the mounting strategy. In general, it's possible to save installation costs (labor and materials) by installing larger modules, such as the 300W ASE panels, instead of smaller ones, such as the Siemens or BP 75W modules. In addition, the ASE modules have a mounting system that was tailor-made for the panels and specifically designed to be simple, which should further reduce installation costs. We assumed that residents will install a time-of-use meter.

There are a few charges that we have not included because they are unknown. These include shipping charges, as well as additional permitting and installation costs.

Permitting Requirements for PV Installation

County Requirements (per John Roberts, Humboldt County Building Department)
The county requires a drawing of the proposed system showing the components and their proposed layout. An electrical schematic is also required. The county requires compliance with the National Electric Code. Both an electrical and a building permit must be purchased. The total cost of permits ranges from $200 to $500 and includes the plan check, all inspections, and document processing. Permit cost is based on the total value of the proposed system, and the permitting process can last up to a month.

The county is willing to give residents (and the task force) the option of submitting applications for a generic system. The total permitting cost in this situation will be $150 and applications may be "fast-tracked" through the department within a week.

The county points out that they have no jurisdiction in Eureka, Arcata, or Fortuna. They do, however, have jurisdiction in Trinidad, McKinleyville, and Willow Creek, among other towns. Up until the springtime, the county office staff had seen approximately 2 applications for PV systems in the last three years. Since May, more than 12 applications have been submitted from within Humboldt County.

City of Arcata Requirements (per Dean Renfer, Arcata City Building Department)
The City of Arcata building department also requires a drawing of the proposed system, an electrical schematic, and compliance with the National Electric Code. They also require a letter from PG&E. An electrical permit and maybe a building permit will have to be issued. The cost of the permits and application is around $60 and the process takes up to 3 weeks. City staff have seen approximately 4 or 5 applications in the last year.

If HETF members wish to launch a truly successful PV program, they should address every barrier that has so far kept most grid-connected households from putting PV on their roofs. To this end, HETF should consider ways to further reduce permitting costs and streamline permit processes for PV installations.

Partnering with SMUD

SMUD offers the PV Partnership to any municipality that would like to join them in promoting the installation of PVs on rooftops. The PV Partnership offers the high volume buying power of the SMUD program, access to public relations materials, training programs for installers, and access to the administrative know-how of a group that has been implementing a residential rooftop PV program for several years. These are very valuable. The head of the PV Partnership program is Vince Schwent, who can be reached by e-mailing vschwen@smud.org or calling (916) 732-5501.

One of the biggest advantages to working with SMUD is that a 2 kW PV and inverter combination would be available for $3/W. The retail cost of most PV/inverter combinations is $5-8/W.

There are some concerns in working with the equipment offered by SMUD. First, they use Energy Photovoltaics EPV-40 modules, which are amorphous, a different technology from the crystalline modules recommended by SERC. Amorphous modules are somewhat less expensive than crystalline modules on a per-watt basis due to lower manufacturing costs. However, new amorphous modules have a much lower efficiency than crystalline modules, and their efficiency drops further during the first months of use. In addition, PV users have less long term experience with amorphous modules than with crystalline modules. Data we found is limited to three years and shows their performance to be acceptable but less satisfactory than that of crystalline modules.

Because amorphous module efficiency is about half that of crystalline module efficiency, twice as much module surface area is required to produce a given amount of energy using amorphous modules. This means only 0.5 kW systems could be installed on rooftops that have 100 square feet of mounting area available. If 1000W inverters are purchased in bulk to allow for larger systems, the inverter installed will have twice the capacity needed for the system. If, on the other hand, the resident has sufficient roof space and chooses to install a full 1 kW amorphous array, the cost of mounting (both equipment and labor) will be higher than for the smaller 1 kW crystalline system.

No tailored mounting structure exists for the EPV-40s. However, custom mounting should not be difficult. SMUD uses Unistrut, which has been cut to size. The lack of a set mounting structure to accompany the modules adds risk to any cost projection.

SMUD has had a very poor experience with the Trace/Xantrex inverter. According to Don Osborn, the head of the PV pioneer program, SMUD has had to service or remove every Trace inverter that has been installed. Trace has tried to fix the problem, and SMUD is in the process of evaluating the fixed inverters. Since SMUD is installing 2 kW systems, the 2.5 kW Sunny Boy inverter is an alternative, which SMUD is also evaluating.

In summary, while SMUD is certainly offering the best available pricing on PV systems, we do not recommend taking advantage of their bulk purchase arrangement, due to our concerns about the equipment SMUD offers. We do suggest partnering with SMUD to learn about the administrative aspects of rooftop PV projects, as well as training, installation, public awareness, and other efforts.

In August 2001, a SERC engineer visited SMUD, where staff were willing to give us the benefit of their experience and talk about lessons learned:

1. Support of local building department officials is critical. Consider doing a demonstration on a building of their choosing. Get to know them well. Set up data collection equipment at the demonstration site. Develop a survey form for site visitors and for those who might be interested in purchasing a PV system (copies of SMUD's questionnaire and letter of intent are attached).

2. Decide upfront what services you will provide and how large the initial program will be. SMUD has an entire staff providing administration of its PV Pioneer Program, which includes all phases of a PV installation: billing history, participant qualification, roof inspection, system design, permitting, installation, and data collection.

Time-of-Use Rates and Net Metering

The wholesale cost of electricity varies with the level of total demand on the electric grid. During times of heavy demand, electricity is much more expensive for utilities to provide than during times of lighter use. Traditionally, electric utilities have billed customers at a flat rate at all times of the day and year. This rate has been based on the utility's average cost of producing electricity.

In recent years, with deregulation, industrial and commercial customers have been able, and have in some cases been required, to purchase electricity at rates based on time of day and time of the year. This is referred to as a "time-of-use" (TOU) rate. Customers whose primary use is during lower rate periods can save significant amounts of money by shifting to TOU metering. Very recently TOU rates have become available for residential customers.

The most common version of TOU available for residential customers in California has two times of day (on-peak, off-peak) and two times of year (summer, winter). Summer is May 1 through October 31; winter is November 1 through April 30. Peak is noon through 6 p.m. Monday through Friday; off-peak is all other times of day. Rates are highest during summer peak and lowest during winter off-peak and at intermediate levels for the other periods. Currently the rate for summer peak is approximately four times the rate for winter off-peak.

For residential customers who generate some of their own electricity, a billing mechanism called "net metering" is available. With net metering a customer is billed a connection charge of approximately $5 monthly and is also billed once per year based on the difference between the amount of electricity that their system sends into the grid and the amount of electricity that they use from the grid. Net metering is beneficial for all grid-connected customers who generate some of their own electricity.

TOU can be combined with net metering. With this combination customers are charged and credited separately at the applicable rate for each of the four time periods. This is especially beneficial for customers with PV (photovoltaic) systems in the North Coast area because generation is maximum on sunny afternoons during the summer peak period, while cool coastal temperatures eliminate any need for the air conditioning that drives high electric demand in the rest of the state. Customers are on average credited at a high rate for generation and charged at a low rate for use. For customers with residential PV systems this can significantly lower their average cost of electricity as compared with using the flat rate for electricity. In spite of this local economic advantage, however, the average cost of electricity with a PV system will still be

significantly more expensive than without a PV system. A customer must pay a one-time charge of $277 to have a TOU meter installed.

Table 2 compares net electricity costs with and without the TOU rate for a customer with a 1kW (AC) PV system. The table shows estimated percentages of year-round electrical energy used and generated by the household during summer and winter on- and off-peak periods. Based on when energy is produced and consumed and the estimated average energy (kWh) generated and used per day, the table provides a calculation of what electricity would cost the homeowner with and without TOU billing. These costs reflect the capital cost of the PV system and the monthly utility charges for electricity used in excess of electricity generated.

The TOU rate yields net electricity costs about 14% lower than flat rates. In this example, payback time for the $277 TOU meter would be approximately 16 months. A customer with a 1 kW PV system would save money in the long term with TOU rates compared to remaining on the PG&E flat rate. Note, however, that even the lower TOU rate yields net PV electricity costs about double current residential PG&E rates.

Table 2: Average Electricity Costs Example for a 1 kW (AC) PV System

	Summer On	Summer Off	Winter On	Winter Off
Use	10%	30%	10%	50%
Generate	27.4%	32.7%	16.5%	23.4%

Generate kWh/day	Use kWh/day	TOU Net $/kWh	Flat Net $/kWh
4.1	15	$0.235	$0.273

Notes and Assumptions:

- Generation percentages shown are based on average weather for Arcata. Consumption quantities and percentages are for a hypothetical family in the North Coast zone.
- PV @$0.66/kWh after CEC rebate (excluding price of time-of-use/generation meter)
- Array altitude (tilt): 26°
- Azimuth: 180° (due south)
- Shading: none
- Annual generation calculated using PVWATTS (http://rredc.nrel.gov/solar/codes_algs/PVWATTS/California/)

Conclusions

As SERC pointed out in our first report to the HETF, PV systems are costly, even when rebates and net metering are applied. Homeowners should only seriously consider investing in a PV system after taking all cost-effective measures to make their homes electrically efficient. Switching to compact fluorescent lights and buying efficient appliances will cost less initially and yield greater return on investment than installing a PV system.

Having said this, there is a lot of local interest in home renewable energy generation. Putting a PV system on your roof does increase the amount of green energy on the grid, and it's a fun and exciting way to help California and Humboldt County achieve energy security. By applying the recommendations in this report, the HETF will be able to help local residents acquire high quality home PV systems at reasonable cost.

Attachments

- California Energy Commission Emerging Renewables Buydown Program Reservation Request Form
- SMUD PV Pioneer Program Letter of Intent
- Solar PV Pioneer Questionnaire