Case Study: Solar Panels

Physics 80

14 February 2006; *due Thursday, 23 February 2006*

Energy and the Environment

In the fall of 2003 my wife and I decided to invest in a solar photovoltaic system, which was installed in December and January, but was incorrectly wired. It did not actually produce power until 20 February 2004. Since then, it has functioned properly according to specifications, as much as I can tell. We have a metering agreement with SCE such that we are billed annually, although we receive a monthly statement reporting the electricity we have drawn from the network. When the photovoltaic system generates more power than is being consumed in the house, the electricity meter spins backward, thus lowering our consumption for the month. As far as I understand, the meter does not pay attention to the time of day at which this generation takes place; it merely lowers the monthly total.

In the following document I describe some of the background information that went into our decision to invest in the solar PV system. As you well know, I never took economics, and did not have the "benefit" of Chapter 5 in Tester *et al.* However, I did conduct my own economic analysis which led me to install the system. The purpose of this assignment is for you to investigate the economics of the project and to advise what the likely payback period is apt to be.

Background

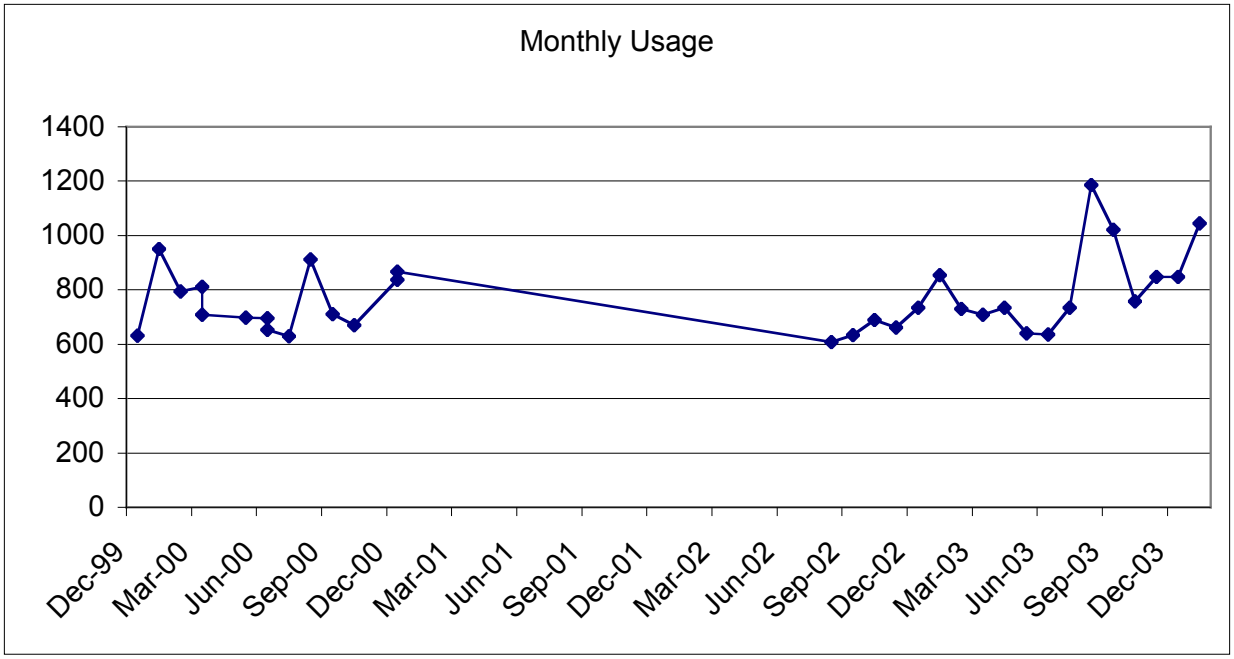
Solar PV systems tend to have rated powers that are multiples of the capacity of the inverter, which is the device that converts the DC current generated in the silicon panels by the absorption of sunlight into the alternating current of the power grid. A common capacity of these inverters is 2.5 kW, so that to install of 5-kW system one uses two inverters and wires an appropriate number of panels to each one. Typically, an inverter features an LCD display that reports the output of the panels. I upgraded to a modem that allows me to sample and record the output on my computer over an RS-232 (old-fashioned serial) cable. For most days, therefore, I have some record of the output of the panels from which data I can, for example, demonstrate conclusively that the sun shines longer in the summer than the winter!

In general, panels should be oriented on a south-facing roof. Our roof faces either southeast or southwest. We put the panels on the southwest-facing roof, so that they would generate more power later in the afternoon, when demand is higher.

I have three children (all boys), none of whom necessarily turns out lights with as much alacrity as he should. Same story for my wife (except that I have only one of her). Besides the normal appliances, we have a swimming pool/pump, which is a major draw of electricity and accounts for a significant portion of our total bill, particularly in the summer. My boys are currently in 10th, 9th, and 5th grades.

Our single-story ranch-style house has a combined heater/air-conditioning unit mounted on the roof. We typically avoid running the air conditioner in summer, except when the days are exceptionally hot and the temperature does not drop after sundown. Rather, we open the house after sundown and run fans to pull cooler outside air into the house until morning.

Saeta household electricity usage



The above graph summarizes our household electricity usage (in kWh/month) over several months before sabbatical and then after sabbatical.

Southern California Edison's rate structure

SCE has changed its rate structure several times since we moved to Claremont in 1995. The charge for electric power depends on whether the power is above or below the baseline rate, which depends on the season. Our summer baseline is 6.75 kWh/day, while the winter rate is 11.71 kWh/day.

Below is a table showing the price of electricity (cents per kWh) and the various epochs at which the rate structure was in force. Until May, 2001, there were only two rates. For example, in the summer of 2000, I was charged $0.12318/kWh for the first 6.75 kWh/day I used, and $0.14157/kWh for energy above that rate. Beginning in

From	To	Baseline	Over	130-200%	>200%
May-95	Apr-96	12.419	14.277		
Apr-96	Jun-96	12.318	14.168		
Jun-96	May-01	12.009	14.157		
May-01	Jan-03	13.009	14.157	15.157	19.704
Jan-03	?	13.009	15.157	19.704	23.645

Rebate program

When we decided to install the panel system, the state of California was offering a rebate program to cover solar PV systems: 50% of the installed cost (minus the cost of the permit). In addition, there was a 15% state income tax credit on the net cost to the consumer (i.e., me).

Roof

To affix the panels to the roof, it was necessary to install a number of anchors to the rafters. This required removing the roof tiles, installing the anchors, then cutting the appropriate tiles to fit around the anchors. A roofer determined that the existing roof, which was approximately 25 years old, was at the end of its useful life and was leaking (or ready to leak) in a number of places. He recommended re-roofing the entire section of the roof, which he would do using a double layer of felt, so that the revised version should last 50 years, instead of 25. Of course, when the roof was off, he discovered damage elsewhere so that the roofing job became more extensive.

Panels

A number of vendors manufacture polycrystalline silicon solar cells. We went with the cheapest manufacturer, the Korean company Kyocera, which is one of the largest. The combination of our solar panels and inverter yields a peak rated power of 2.35 kW. The panels are warranted for 25 years by Kyocera, and subject to an expected degradation rate of 0.2%/y.

Additional information about the project is available in a spreadsheet on the WIKI portion of the course web site. See the Current Announcements section on the front page.

Financial situation

Assume that we have sufficient cash sitting in the bank, where it was earning a paltry rate of interest (something like 1%/y), to cover the complete cost of installation, and that we could have chosen to take this cash and invest it instead in any variety of financial instruments.

Questions

1) What is the expected payback period of the solar array? Please be very clear on what assumptions you make.

2) If we had hired you as our consultants back in the fall of 2003, would you have advised for and against the project? Why or why not?

You may perform this analysis on your own or in collaboration with another student in the course. In the case of a collaboration, please submit a single report for the team.