



Photovoltaic Case Study

Interview with Mike Simpson – August 2006

Introduction

Photovoltaic or solar cells can directly convert sunlight into electricity. Most of these cells are made from a crystalline substance called silicon, one of the Earth's most common materials. In two to four years, photovoltaic modules will produce as much energy as it takes to make them. They usually have a 25-year warranty and, although they deteriorate slowly, they can continue to produce clean electricity for many more years.

The simplest photovoltaic cells power small devices such as watches and calculators, while more complex systems can light offices or homes and provide power to the electrical grid. Solar electric systems consist of three main items: *PV panels or modules* that convert sunlight into electricity (direct current or DC); *inverters* that convert that electricity into alternating current (AC) so it can be used by most office or household appliances; and sometimes *batteries* that store excess electricity produced by the system (some grid-connected or net-metered PV systems do not require batteries). The remainder of the system comprises equipment such as wiring, circuit breakers, and support structures.

All installations should be in unobstructed direct sunlight and mounted on a sturdy structure. The modules should face true south or maximize for sun exposure if shading occurs part of the day. Ideally, the vertical angle of the modules should be perpendicular to the sun. In summer, when the sun is high overhead in Smithers, the modules can have a flatter angle. For lower winter sun, they should be angled more vertically. The rule of thumb is 23 degrees above latitude, which would be around 77 degrees in Smithers.

PV systems can be set up as autonomous or stand-alone, as hybrid systems (supplemented with other power sources) or tied into the utility grid. While many configurations of PV systems exist, this case study examines a hybrid photovoltaic-generator, off-grid system, providing a good example of the steps involved in installing a PV system and challenges investors might encounter.

Case Study

Mike and Gail built a new home in Driftwood just outside of Smithers, BC on farmland. It was primarily designed to be a guesthouse that would be inexpensive and low-impact to build and maintain. The location is ideal for wind and solar power, located on a ridge with moderate wind speeds. The

home, accordingly, was designed to accommodate a 1000-watt wind generator, which is soon to be installed. The home faces south, allowing for maximum sun exposure, and has a sloped roof, facilitating solar panel installation. The home is 1.6 kilometres from the grid and the nearest neighbour is approximately 3 kilometres away. The home is 1 storey with a loft and 660 square feet, with two people living in it. Though the home is small, its cathedral roof design makes it seem more spacious. Currently there is a hybrid PV-generator system with a battery bank installed with future plans to expand to incorporate a wind power system. This design was chosen for its cost effectiveness and as a testament to the benefits of being environmentally conscious through the use of renewable energy.

In addition to the PV system installed, the home is energy efficient in several other ways. The home is designed to be passive solar, with large windows facing within 15° of due south and upper windows which help absorb heat and provide natural lighting. Of the windows used, 75% were recycled double paned efficient in line with the overall effort to use low impact and local materials. Locally milled wood and siding from the Kispiox mill were used. The house and crawl spaces are R-20 insulated and wrapped in Tyvek, a commercial house wrap. Despite the general effort to use environmentally sound materials, for lack of time and lack of alternatives, asphalt, plywood, and dry wall were also used.

Special consideration was taken to be energy efficient by using compact florescent lights, dimmer switches to control the voltage of the lights, and an LED flat screen television. The home uses a Kenmore© refrigerator from Sears© which was the least expensive (\$800) and most efficient fridge Mike could find (376 kWh/hours per year). Additional electrical needs come from the use of a stereo, the occasional use of the microwave, laptop and power tools. The propane stove is the only appliance with a phantom light. There is also a propane on-demand hot water heater and a 1½ horsepower jet-pump that is overpowered. The home is heated by the smallest size DutchMaster© wood stove which is highly efficient, using 40% less wood than a regular wood stove; the stove also has a catalytic converter. They use a propane space heater as a backup source. With conservation in mind, the toilet, shower, and taps are low-flow and energy efficient. These energy demands amount to a household electrical load of approximately 6 kWh/day. The PV system just meets





the electrical demands during the summer months. In the summer the generator is used about once a week to meet high-energy demands including power tools such as a planer and table saw.

There were two primary builders who concurrently worked their full time jobs and conscripted the help of friends for various tasks. The entire building and installation project took 6 months to complete and has been functional since October 2005. Mike Simpson, one of the main builders, was experienced in the installation of PV systems.

Installing a PV hybrid system was the most cost effective power generation system. It would have cost \$25,000 to connect the home to the grid, whereas the components of the PV system cost only \$6,000 and the wind system is projected to cost another \$6,000. The total cost for the system was still significantly less than it would have cost to connect to the grid. Furthermore, the rising costs of fossil fuels made the predictable cost of solar power appealing. Also in favour of an off-grid system were recent improvements in telecommunications technology to allow radio Internet access and cell phone use.

Mike designed and built the home to accommodate an off-grid hybrid system, whereas many PV systems are added to houses after they are built. This enabled the house to be prepared to simplify using the PV system, such as laying wires throughout the home and wiring in the charge control unit to have computer access to the system. In this way, the system was relatively simple to install and is easy to operate. There are only a few limited troubleshooting and maintenance requirements.

In terms of troubleshooting, the system needs to be programmed, the batteries occasionally equalized, and the inverter manual consulted for minor issues such as determining how to set inverter stage charging. On a day-to-day basis the system and voltage are checked (and re-set if overloaded), and snow and ice are brushed off the panels in the winter. Batteries should be checked every three months and topped up as needed. The solar panels were

temporarily located on the ground in front of the home due to a winter installation but they are now mounted on the roof.

Considerations & recommendations:

1. Working with the batteries is very dangerous and requires a great deal of knowledge. The batteries must be sealed from the home, well ventilated, and ideally kept from freezing which limits where they can be stored. Temperature is a major consideration.
2. The inverter can be very noisy, therefore install it outside or buy one that is of good quality; keeping in mind that inverters have to be closely connected to the battery bank to avoid losing efficiency.
3. Many dealers are located far away, which increases transportation costs. Most of the materials used for the photovoltaic system had to come from Vancouver.
4. The larger the load, the less nominal power batteries can generate. This means in order to accommodate larger loads one must have a substantial battery bank or hybrid system.
5. The surge capacity of induction motors needs to be carefully considered before hand; table saws, planers and other motors require more power when they first start up then they are rated at. This can overload inverters.
6. It is recommended that people installing a system for the first time do so through a company that will offer ongoing advice and assistance.



<u>Key System Components</u>	<u>Description</u>	<u>Cost*</u>
4 Sharp © Solar Panels	123 watts each	\$700 each
1 Xantrex© Inverter	2,000 watt capacity & surge capacity: 3,500 watts	\$1,500
1 Charge Control Unit	40 amps	\$150
Distribution Box	Includes control panel	\$100
12 Trojan© golf cart Batteries	6 volt→Series→12 volts & Parallel→2,000amp	\$1,000
Miscellaneous		\$600
AC Honda © Generator	3,000 watts (gas)	\$2,200

*Builder was able to get special deals therefore costs are not necessarily reflective of market prices



