SOLBAKKEN:
Update on a Net Zero Energy-Cost Home

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Last year we presented preliminary performance results for a custom residence in San Pedro Creek, New Mexico, which was created using an integrated design approach. Passive solar heating, natural ventilation and geothermal cooling, active solar thermal space heating and domestic hot water, and a 5kW photovoltaic array for power production combine to produce thermal comfort and electrical power.

OVERALL DESCRIPTION

The design was conceived from the very beginning as a solar home and is elongated on the east-west axis to provide direct or indirect solar access in all living spaces while taking advantage of both close and distant views. The original building program included three bedrooms, two home offices, living room, den, dining, kitchen, bathrooms, garage/workshop and utility room – all on the ground floor. A late addition to the program was a second floor "view room" and deck in order to have a retreat space that had 360 degree views. The highly insulated 4,000 square foot home incorporates 2 x 8 framed walls with R-25 insulation, clad-wood windows with Low-E glazing, R-23 Rastra block stem walls, and R-38 ceiling insulation. The passive solar heating design includes the direct gain heating of south side rooms, a clerestory above the central hallway that irradiates a central mass wall of decorative concrete block, and a sunspace at the entry that houses both plants and birds – and creates a thermal transition from exterior to interior. Special features of the site design are the enclosing garden walls, on the south and east, the tennis court, and the passive solar heated horse barn.

PHOTOVOLTAIC AND SOLAR THERMAL SYSTEMS

The heating system was designed as a unique hybrid that interconnects the solar thermal system with the PV system and does not use any gas or propane. The photovoltaic system incorporates 30 - 167W panels, is rated at 5 kW, and is "grid tied". There are two electric meters: the standard PNM meter runs backwards when the PV's produce more power than the house is using. A second meter records *all* of the electrical output of the PV system and PNM will pay $0.13/kWh for this power for 12 years. Nine solar thermal panels are hung on the south side of the enclosing garden wall and provide heat for the radiant floor and the domestic hot water by way of three heat exchangers in the 750-gallon, highly insulated, underground storage tank.

The backup heating, for times when the solar thermal system is drawn down, will go first to the PV system for heating of the water for the radiant system in a high efficiency, tankless electric water heater. The Architects were concerned that the annual costs for space heating with grid-supplied electricity could be extremely high for this situation. The Owner, however, showed that most such conditions would be short lived. When this situation occurs during cloudy daytime hours, the PV's are still generating electricity (though at a reduced efficiency) while the solar thermal panels are relatively ineffective. Consequently, the thermal and cost problem is on cold winter nights after several cloudy days. This situation is alleviated by the extensive thermal storage capacity of the central mass wall and the stained concrete floors; by lower thermostat settings at night; use of insulated window shades; and by two high-efficiency, low emission wood stoves. The PV's are ground mounted and un-shaded for optimal efficiency and ease of possible expansion. The solar thermal panels are mounted vertically on a garden wall to avoid potential summertime overheating. The temperature in the storage tank has never been observed to drop below 80F.

WATER HARVESTING AND EARTH COOLING TUBE

The entire roof was designed to collect and channel rain and snowmelt to an underground cistern of 10,000 gallons that is also fed from the tennis court drainage system. The water is used for drip irrigation of the garden areas in this water-starved climate and may also be used for fire protection. The house has no mechanical cooling system and relies instead on shading, insulation, planting, natural ventilation, and the large temperature differences between day and night for maintaining comfort. To augment these efforts, an "underground cool tube" was installed to take advantage of geothermal cooling. The 10" PVC tube is 200 feet long, is placed about 6 feet under the surface, and has a small fan placed in the gooseneck inlet. The fan moves outside air to a centrally located outlet inside of the house. Contact with the cool earth at this depth cools the incoming air for nearly free cooling. The addition of several parallel tubes to the installed tube would provide improved performance, but the cost of removing rock in the excavation limited this approach. So far the inside temperature can be kept comfortable.

PERFORMANCE

The installation of the solar thermal system and PV's were "in progress" when the house was occupied. Although this led to extra short-term costs for a few months for the owners, it allowed for the establishment of a base case of performance without the active solar and PV assists. A timeline follows that illustrates the value and contribution of the solar systems.

1. The Olsen's move into the house in the middle of October 2004.
2. PNM bills from October 15, 2004 to April 17, 2005 show a total kilowatt-hour usage of 16,350 kWh (or 55.8 million Btu's). Subtracting a reasonable estimate of 600 kWh/month for domestic hot water heating, lighting, plug loads, well pump, cooking and heat gain from the occupants would yield a heating load for the winter of 12,750 kWh. This translates to an auxiliary space-heating load of only 43.5 million Btu's for the entire winter for a 4000 square foot house. The predicted annual heating load*, without* any passive solar contribution, was 142.4 million Btu/yr based on 5500 Heating Degree Days for this location. The passive solar contribution, plus the wood burned in two small wood stoves, contributed 69 % in the "start up" heating season.
3. The Solar Thermal System for domestic hot water begins April 25, 2005.
4. Electric bills for April 15 through October 17 average 723 kWh/month.
5. Electric bills for October 17, 2005 to April 17, 2006 totaled 9,432 kW. Subtracting the 600kWh/month for other uses yields 5,832 kWh for space heating. This equals 19.9 million Btu's for auxiliary heating for the second winter - less than half of the first year. Note: There was a small contribution from the PV system while it was being installed and tested during this period.
6. The PV array was fully grid-tied on April 3, 2006.

7. From mid-April, 2006 to mid-April, 2007, the PV System generated 9104 kWh or averaged almost exactly 25 kWh per day.
8. NET payments from PNM = $33.38 for the first full year of operation!

CONCLUSIONS

The house has performed exceedingly well to date. It is now a net positive energy cost house. In other words, it generates a small financial surplus over the year.

VIEW OF OLSEN RESIDENCE FROM SOUTHWEST

ENTRY SUNSPACE AT OLSEN RESIDENCE