Hot Water Systems

The hot water system was designed to meet the requirements for hot water while minimizing system cost and complexity and maximizing the benefit from the sunlit surfaces of the house. The team chose to use a water-to-water heat pump (WWHP) connected to an earth coupled heat exchanger to provide water heating. This system provides not only domestic hot water but also space heating through a radiant floor heating system. With one system serving two purposes, the cost and complexity are reduced.

The use of PV provided electricity through an earth coupled heat pump to produce domestic hot water also makes more effective use of the sunlit surfaces of the house. Using an earth coupled heat pump system, the 30 gallons of hot water required per day can be heated with a winter COP of ≥3 thus requiring only 1500 Wh of energy per day. During the month of December, the PV modules average 3 equivalent rated hours per day. Thus, the hot water needs can be met with only 500 W-rated of additional PV modules. At a PV cost of $3/W-rated and a power conditioning cost of $1/W, this translates to $2,000 to provide additional PV modules and power conditioning to accomplish water heating using the WWHP system. With appropriate controls to allow heater operation only during the middle of the day, additional battery storage capacity is minimized. In the summer months, when the solar irradiation is more intense and more sustained, the excess power from the additional PV modules can be used for another purpose (powering the electric vehicle). Furthermore, if the house is grid-connected after competition, the excess power not required for water heating can be sold back to the utility providing a economic benefit to the owner and displacing power that would otherwise be generated primarily by coal. In contrast, a solar thermal system would have to be sized to meet the winter heating need but would not have a use for the excess energy available during the summer months.

The hot water system is closely integrated with the space conditioning system and the building controls system. As noted, the hot water and radiant floor heating system both use the WWHP as the source of heat. In addition, the hot water system uses thermal energy rejected from the air conditioning system desuperheater to provide “free” heating for the hot water during the air conditioning season. This recovered heat is predicted to supply 30% of the hot water requirement during the air conditioning season, freeing PV power for other applications. The energy used for water heating is also minimized

through the operation of the control system. The control system dispatches the WWHP to provide heat to either the radiant floor system or water heating system. During unoccupied hours, the control system can prevent operation of the WWHP for water heating, allowing the tank temperature to drop and reducing storage losses. In the summer, the control system can delay operation of the WWHP to allow additional time for the desuperheater to heat the water.

Careful integration of the hot water system with the space conditioning system and the control system reduces the initial cost of the hot water system; provides free heating through the operation of the desuperheater; allows the use of a very high COP earth coupled heat pump; and provides for scheduled operation of the hot water system. Moreover, since PV power is the energy source for the system, excess energy arising from these energy saving measures and from the increased irradiation during summer months can be used for other (non-thermal) purposes such as powering an electric vehicle or returning energy to the grid in net-metered grid connected applications.