Solar Air Heating Re-Roof of the Gaffney Fitness Facility Pool
July 14, 2017

Summary:

The solar air heating re-roof of the Gaffney Fitness Facility Pool incorporated a solar air heat recovery system to preheat outdoor air for the POOLPAK pool heating system.

The 8,750 square foot pool re-roof was completed in October 2016 and the solar air heat recovery system was activated on November 1, 2016.

A monitoring system was installed to measure solar air temperature, outdoor air temperature and fan ON-OFF times.

The system turns ON and OFF automatically whenever solar air is ~12 degrees F warmer than the outside air and the outside air is below 75F.

The system delivers 2,960 cubic feet per minute of solar heated air that is between 13 and 36F warmer than outdoor air temperature.

There are 609 hours per year, when the pool is open, that the system will deliver solar heated air at an average temperature rise of 22F above outdoor air temperature

The total energy delivery in a typical year, would be 42 million BTU, when the pool is open. Average energy delivery is 78,400 BTU per hour.

The electrical energy to run the fan requires 1554 Watts and consumes 946 KWHR per year

Cost to operate the system will be about, $75.71 per year at $0.08/kwhr

Savings of natural gas in the boiler would be about $200 per year with $5.85/million BTU gas burned in a 95% efficient boiler.

Additional savings from the reduced heat loss through the roof, due to the added insulation of the solar heated air layer above the old roof, are equal to about $273 per year.

Savings from not having to tear off and dispose of the old roof and provide weather protection during re-roofing is estimated at $52,500, or $1,787 per year when amortized of over the 40 year life of the roof.

Only about 20% of the annual solar heat available from the roof is used, just during the hours when the pool is open. If all the solar heated air from the roof were used during all hours it is available to offset gas heat from the boiler, there would be a savings of 226 million BTU per year and cost savings of $1,395 per year.

System description and operation:

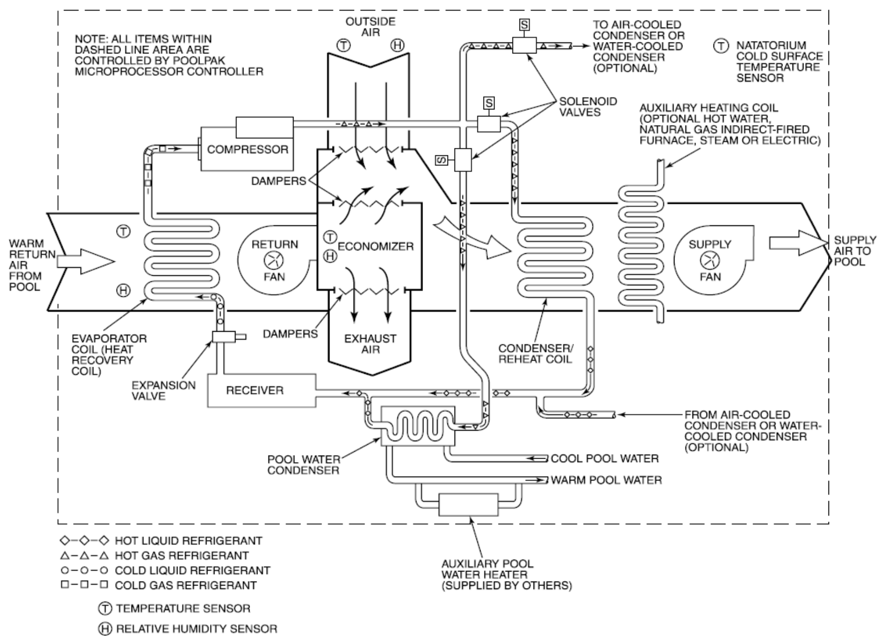
The Gaffney pool solar re-roof uses a system similar to the Gym solar re-roof installed in 2012. A black metal roof is installed above the existing roof with a 3 inch solar air space between the bottom of the metal panel and the old concrete tile ballast on top of the old roof. The solar air space allows air within the space to be heated by the bottom of the solar heated roof panel.

Air is introduced at the northwest eave and pulled out of the air space a few feet below the ridge at the southeast corner of the roof. A duct is installed from the roof air outlet, down the side of the building to below the sundeck. A solar fan pulls air down the duct and exhausts the solar heated air toward the outdoor air intake of the POOLPAK. The fan is sized to deliver the minimum outside air specified for the POOLPAK.

The solar air fan is controlled by a differential temperature controller inside the pump room of the pool. The fan is set to turn ON when the outside air is above 75F and when the solar air in the roof is 12F hotter than the outdoor air at the POOLPAK. The fan stays on until the solar air temperature drops below 4F hotter than outside air. When the solar air heat recovery fan is turned ON, it floods the outside air intake and the POOLPAK outdoor air temperature sensor with solar heated air.

The POOLPAK operates with an economizer on the outdoor air intake. When the outdoor air is warm enough and dryer than the return air (~82F, 60% relative humidity) from the pool, the outdoor air damper will open to use outdoor air for space heating and dehumidification, instead of 100% use of the compressors and supplemental heat from the gas fired boilers.

Figure 2-2. SWHP SR System Schematic



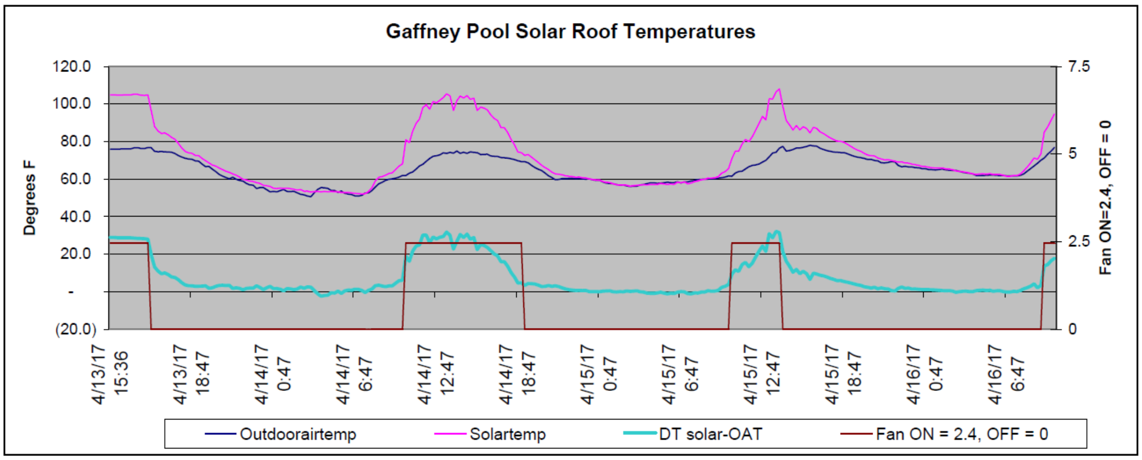
The POOLPAK also air conditions the pool area during the cooling season. When cooling, the compressors will be used to cool the return air and excess compressor heat will be exhausted to an air cooled condenser. During those periods, there is no need for solar heated air. The outdoor air temperature, above which solar heat is no longer useful, is 75F. To stop solar heating when the outdoor temperature is above 75F, a bulb thermostat is installed above the POOLPAK and wired in series with the solar roof air temperature sensor.

There are 3,320 hours per year with adequate solar energy to raise the solar air temperature 12F above the outside air temperature and initiate solar heating. Of those hours, there are 1,350 hours per year when the outdoor air temperature is above 75F in the Washington, DC area and solar heating of the POOLPAK is turned OFF.

With winter low sun angles on the roof and high outdoor air temperatures during the mid summer, most of the operation of the solar roof fan will occur during the spring and fall when the higher sun angles contribute to greater solar heating and outdoor temperatures are below 75F. Once solar heated air is available, the solar fan turns ON and floods the outdoor air temperature sensor and outdoor air intake with air that is warmer than outdoor air. The POOLPAK economizer will open the outdoor air damper as it determines the best use of solar air or pool return air.

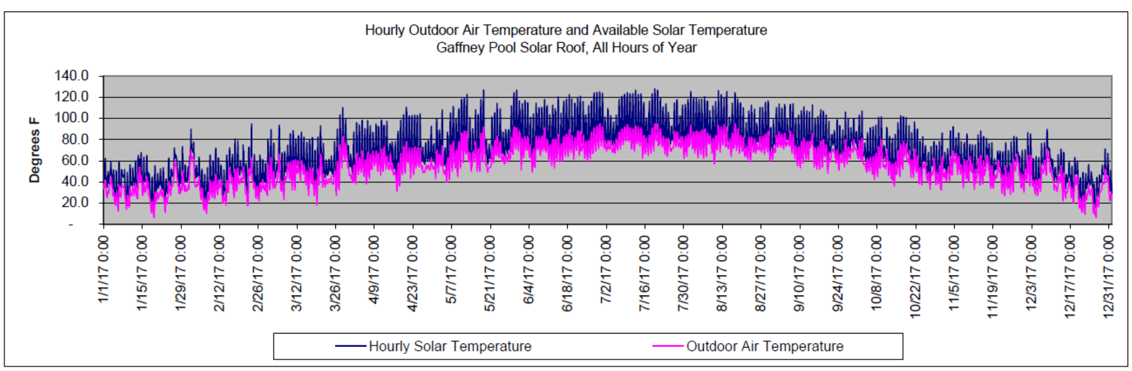
In the spring, the higher sun angles cause the solar roof to generate higher temperatures. On April 14th, at 12:47 PM DST, with sun angle 43 degrees above the horizon, the solar roof air temperature was 101F and outdoor air temperature was 74F.

In mid-April, the solar fan turned ON between 9:30 DST and 10:30 DST in the morning depending on the solar and weather conditions. On several days the solar fan turned OFF when outdoor air temperatures rose above about 75F, as can be seen on the chart below at 14:47 on 4/15/17, when the outdoor air temperature rose above 75F.



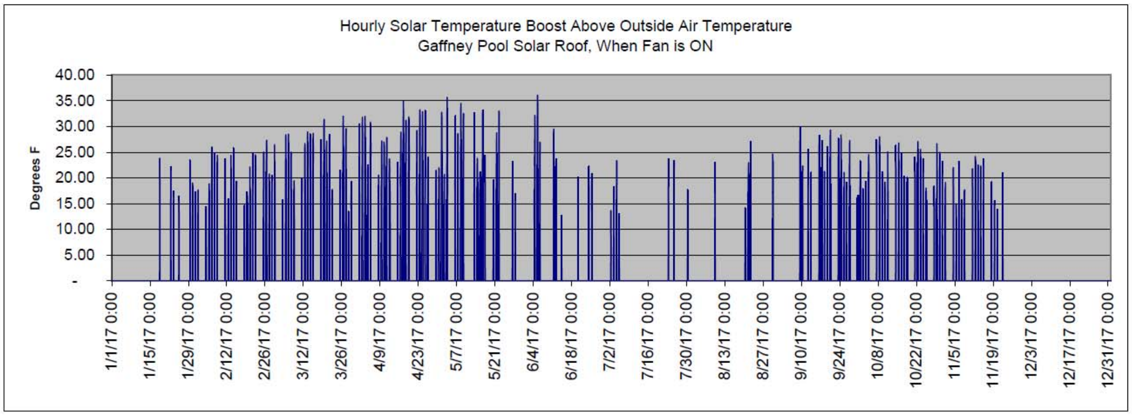
Using the monitored data, American Solar was able to confirm that the pool roof solar air temperature could be modeled using the same predictive algorithm developed for the earlier gym roof project, when accounting for the different roof slopes.

The algorithm was used along with typical meteorological year weather and solar data and solar position data to predict the solar energy temperature at all hours of the year. There are 3,320 hours per year when the solar air is more than 12F warmer than the outside air. These are hours when the solar heated air is available to be delivered.



The actual hours per year when the solar air would be used was determined by accounting for the pool operating hours (44 open hours/168 hour week) and the constraint that the solar air would not be used when the outdoor air was above 75F, when cooling was required. Those actual solar delivery hours are shown below plotted with each hours' temperature boost above outdoor air temperatures. There are a total of 609 hours per year when the solar heated air can be used by delivering it to the outdoor air intake when outdoor air temperatures are below 75F.

During the winter months, with low sun angles there will be no solar energy delivery to the POOLPAK. In the summer months, the solar air may be delivered only during a few cool morning hours, before the outdoor air temperature rises above 75F and the POOLPAK switches to cooling.



The annual solar energy delivery to the outdoor air intake is calculated by the multiplying solar air mass flow (#/hr), by the temperature rise above outdoor air temperature, by the specific heat of air, (.24BTU/#/deg-F), counting each ON hour. Heat energy delivery varied from 112,000 BTU/hr with a 36.9F solar air temperature rise down to 12,600 BTU/hr just before shutting OFF at 4F above outside air temperature.

Total annual solar energy 'available during all hours', at the POOLPAK outdoor air intake, is 215 million BTU. If this energy is supplied by a gas boiler operating at 95% efficiency, it would save 226 million BTU in natural gas use. The energy 'available during pool operating hours', at the POOLPAK outdoor air intake, is 42 million BTU with estimated boiler gas savings of 45 million BTU.

Cost savings occurred in 3 areas; 1) gas savings from preheating air for the POOLPAK, 2) heating savings from the added insulation of the solar heated air layer above the old roof, and 3) tear off and disposal of the old roof.

Cost savings for preheating the POOLPAK are calculated at $200 per year (gas savings $275, electric cost for the fan -$75). Reduced building heating cost is estimated at $275 per year based on similar savings per square foot calculated on the adjacent gym roof of similar design. Tear off and disposal cost savings are estimated at $6.00 per square foot, amortized over the 40 year life of the roof, for an annual cost savings of $1,312 per year.

Total cost savings are $1,787 per year. Over the 40 year life of the roof, savings would be about $70,000. This is approximately 2.5 times the cost of the added solar heat recovery system.