Army Research Laboratory:

# Site of the Largest Solar Air-Heating Roof in North America

American Solar, Inc. designed and installed the largest solar air-heating roof in North America at the Army Research Laboratory (ARL) in Adelphi, Maryland.

The solar air-heating roof on Building 601 includes 11,700 square feet of solar air-heating standing-seam metal roof. The solar roof delivers solar heat to reduce building energy use and costs. The solar roof also provides a much better, weathertight roof to cover the old, worn-out, built-up roof, which had been patched several times but had reached the end of its service life. The combination of a new, long life roof and high energy delivery will save the Army energy and money for years to come.

Building 601 is a 44,000 square foot, 2 story office building, built in 1996. The building's two natural gas fired boilers heat a hot water loop, used for space heating and VAV reheat for air conditioning. An electric hot water tank heats domestic hot water.

With the new solar air-heating roof, solar heated air is delivered to the building to supply: outdoor air preheating, domestic hot water preheating, combustion air preheat and preheat for the VAV loop using a solar-assisted heat pump.

The ***Solar Roof***, is constructed of conventional standing seam metal panels on framing installed at a slope of ¼" in 12" above the old roof. The dark-colored metal roof panels serve as both a weathertight roof and a solar collector surface. Sunlight heats the metal roof surface, which heats the air in the space just below the metal panels. That solar heated air is drawn through fans and ducts to heat the building, hot water, and the VAV reheat loop. ARL's solar roof can heat air at the rate of 45 BTU per square foot per hour, but typically delivers 250,000 BTU/hr and over 55,000 BTU per square foot from October to April. Early testing showed that solar air temperatures can regularly reach 45°F hotter than outside air temperature, delivering solar air at well above 110°F, which is ideal for preheating domestic hot water. Solar air temperature rise from 40 to 60°F above outside air temperatures is typical for solar air heating roofs.

The components of the ARL solar roof include:

- A *Support Structure* above the old roof that creates a solar-heated airspace and secures the new roof to the building.
- *Insulation and a Radiant Barrier* to keep the building cool in summer, warm in winter, and contain the solar heated air.
- *Fans* and *Ducts* to move solar-heated air through the system.
- An *Air-to-Water Heat Exchanger, Storage Tank, Pump, and Valves* to pre-heat water with solar heated air.
- *Controls* to start the fans and pumps when solar heating is required.

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***Outdoor Air Preheat*** **-** The solar heated outdoor air is delivered from five outlets around the solar roof to the outdoor air intakes of the roof top air handlers. The solar air flows are 800 to 1,400 cubic feet per minute, matching the minimum outdoor air required for each air handler. The system saves 250,000 BTU/hr and 1.2 BTUs in natural gas for every BTU of solar heat in the preheated outdoor air.

***Domestic Hot Water Preheat*** **-** The solar air-to-water preheat system is designed to preheat water up to a temperature of 105°F for daily use within the building. The maximum hourly hot water heating load is 20 gallons per hour. The solar air-to-water heating system uses a small 250 CFM fan, an air-to-water heat exchanger, a 20-gallon preheat tank, and a 2-GPM pump. The pump and fan run whenever the solar air temperature is above 90°F and warmer than the water in the storage tank.

This small system heats the 20 gallons of water in the preheat tank from 60°F to 105°F in 45 minutes. It delivers 7,500 BTU per hour to the water with an electric use to run the fan and pump of only 150 watts (~500 BTU/hr equivalent), … *a 93% energy savings compared to electric water heating.*

***VAV Re-Heat for Air Conditioning*** **-** Solar-heated air is also delivered to an air-source heat pump to heat the building water loop used for VAV reheat during the cooling season. The air-to-water heat pump is set to deliver 135°F hot water temperature to the loop when outdoor temperatures are above 60°F. The solar heated air is delivered to the heat pump at between 100 and 110°F, resulting in very high heat pump efficiency and a high (5+) coefficient of performance (COP). The high solar air temperature, and low water loop temperature of 100-120°F required for VAV re-heat, make the S***olar-Assisted Heat Pump*** very economical to run. In fact, the high COP solar-assisted heat pump is more economical to run than the gas fired boilers, which are sized for the larger winter heating load. Testing of the boilers, before the heat pump was installed, showed that they used about 110,000 BTU/hour, cycling on for about 10 minutes per hour to take the loop to 135°F, then shutting down as the loop slowly cooled. This operating cycle resulted in high losses from the hot, idle boilers and the hot loop in the cool building. Operating the high efficiency, solar-assisted heat pump continuously at lower loop temperatures uses less energy and costs about 25% less than operating the boilers. In addition to the low cost hot water, the heat pump exhausts a stream of cool air that can be used to displace the hot, humid outside air that is normally drawn into the building during the air conditioning season.

The solar air-heating roof system at ARL; including the new metal roof, heating systems, and insulation; is installed entirely of standard commercial components. Installation is straightforward using conventional, warranted, roofing and HVAC systems, installed exactly as they are in millions of other buildings. The solar heat recovery techniques are easily applied to all types of buildings that need to lower their energy and roofing costs. When installed during a routine re-roofing of the building, the incremental cost of new “solar panels” is eliminated, as the large roof itself is the solar panel. This makes the solar air-heating metal roof one of the lowest cost, most productive solar energy systems that can be installed.