

**Extended Abstract for ASES 2003:  
Geographical Variation of the Performance of Multi-use Unglazed Collector Systems**

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Unglazed collectors for heating and cooling, as discussed in (Baer 2001), have potential for lower cost and better aesthetics compared to conventional glazed collectors. Hardware cost can be low (e.g., comparable to pool-heating collectors), with additional cost savings from possible replacement of conventional roofing. The aesthetic impact on building roof-lines can be zero because, when fully integrated, the collector could be indistinguishable from conventional roofing (an “invisible collector”, see (Colon 2001)). The system studied here is used for space heating (HTG), space cooling (CLG), and domestic hot water (DHW). This paper presents geographical variation in performance of this system type, a first step toward defining ultimate market potential and identifying the most favorable locations.

**System Description**

System configuration and modeling are detailed in a companion paper (Burch 2003). Unglazed collectors are coupled to a hot and a cold storage tank, which supply residential heating, cooling and pre-heating of domestic hot water. The 2000 ft<sup>2</sup> house has R19 walls, R30 ceiling and 18% of floor area in low-e double pane windows. The model does not vary with location. Since unglazed collectors perform poorly when the collector is significantly hotter than ambient, winter-time DHW/HTG is expected to degrade in very cold climates. Since hot/humid climates have low sky temperature depression generally (Berdahl 1984) and warm nighttime temperatures in summer, the system should not perform well for summer cooling in these climates. This paper quantifies these effects across the U.S.

**Results**

Figures 1-3 compare the annual DHW, HTG, and CLG performance in three cities (Albuquerque, NM, Miami, FL, and Madison, WI) for small, medium and large area collector systems, respectively. [NOTE: For the full paper, performance will be contoured across US maps; results from these 3 sites only were ready in time for writing this abstract.] The largest DHW savings are always seen in Albuquerque, although Madison has more DHW load due to colder mains temperatures. Space heating savings are much larger in Albuquerque than in Madison, as expected in the much colder Madison winter. The Albuquerque system outperforms the Miami system in cooling for all but the largest collector size, despite having less than half the load. Monthly profiles are compared in Fig. 4, which show that most of the cooling savings in Miami comes in the winter months. The largest system in Albuquerque meets ~92% of the total HTG, CLG, and DHW load, versus ~40% of the total load in the other two climates. Of the three sites, Albuquerque is clearly a more favorable location than the other two locations. It is expected that this system type will perform best in the dry southwest where there are significant but not severe heating loads and hot, sunny summers with nonetheless cool nights and cold skies.

**References:**

Baer, S., “Passive Cooling and Drainback Heating with Unglazed Radiators/Absorbers – The Architectural Cool Cell” (TM), Proc. ASES2001, May 2001, Washington D.C. Available ASES, Boulder, CO 80302, U.S.A.

Berdahl, P., and Martin, M., “Characteristic of Infrared Sky Radiation in the United States”, Solar Energy Journal, Vol. 33, 1984. Pergamon Press.

Burch, J., Salasovitch, J., and Christensen, C., “Modeling of Unglazed Collector Systems and Results for Albuquerque, N.M.”, extended abstract submitted to ASES2003.

Colon, C. and Merrigan, T., "Roof Integrated Solar Absorber: The Measured Performance of 'Invisible' Solar Collectors", Proc. ASES2001, May 2001, Washington D.C. Available ASES, Boulder, CO 80302, U.S.A.

## Figures

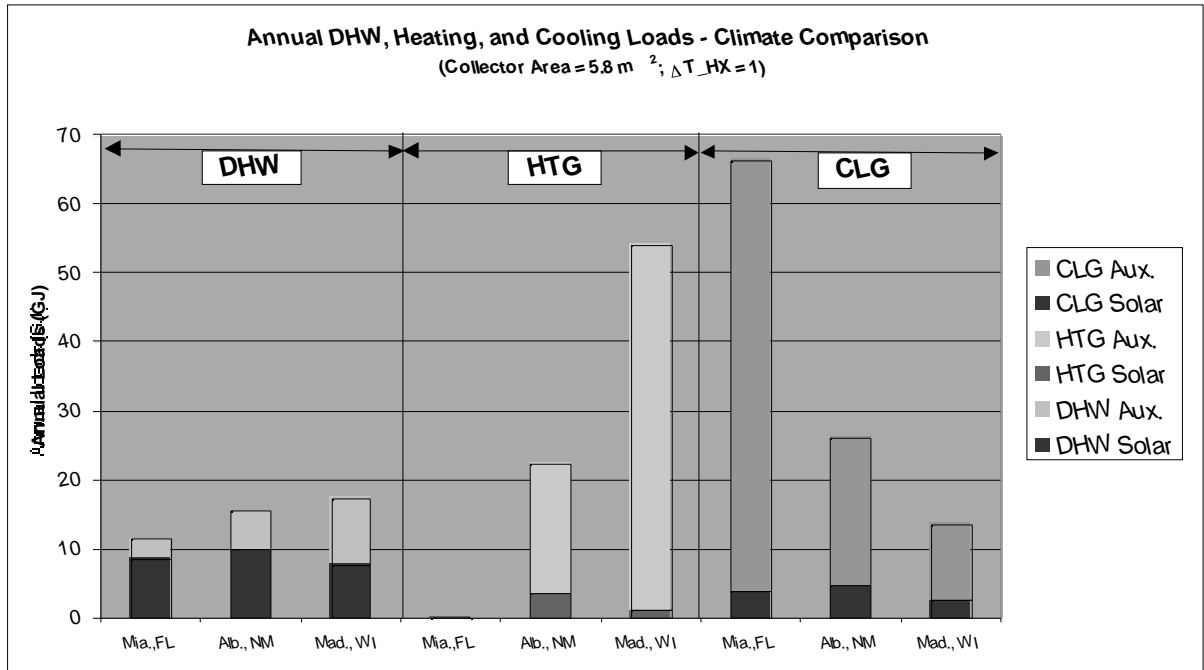


Figure 1. Domestic hot water (DHW), space heating (HTG), and space cooling (CLG) performance of the multi-use unglazed system in three climates. Climates are given at bottom. DHW bars have horizontal lines, HTG bars have vertical lines, and CLG have cross-hatched lines. Dark backgrounds are load met by the solar system, and light backgrounds are auxiliary energy. Collector area is small, 5.8 m<sup>2</sup>. The parameter T<sub>hx</sub> is set to 1C, indicating a large heat exchanger with close coupling to the zone air (see Burch 2003 for more details). The system does well at meeting DHW loads. The space heating load (HTG) is insignificant in Miami. HTG and CLG savings are small compared to the load in all 3 climates.

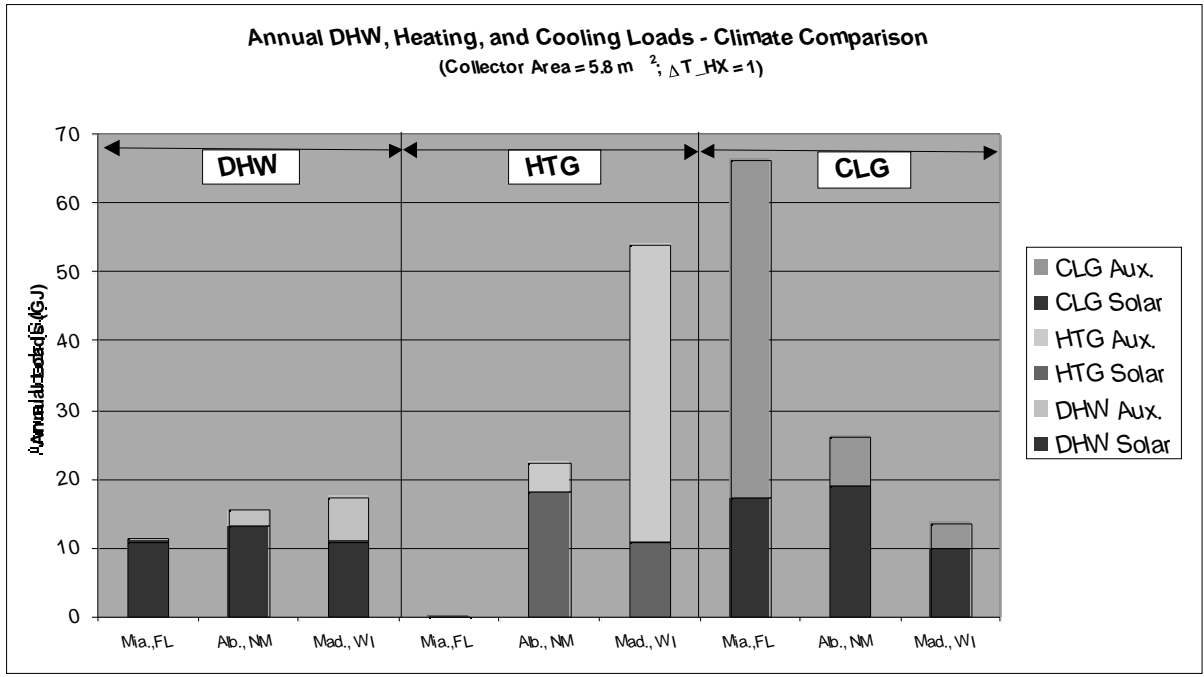


Figure 2. Domestic hot water (DHW), Heating (HTG), and Cooling (CLG) performance of the multi-use unglazed system in three climates. DHW bars have horizontal lines, HTG bars have vertical lines, and CLG have cross-hatched lines. Dark backgrounds are load met by the solar system, and light backgrounds are auxiliary energy. Collector area is fairly large, at 47 m<sup>2</sup>. Most of the loads are met in Albuquerque, except for hottest/coldest parts of winter/summer (see Figure 4).

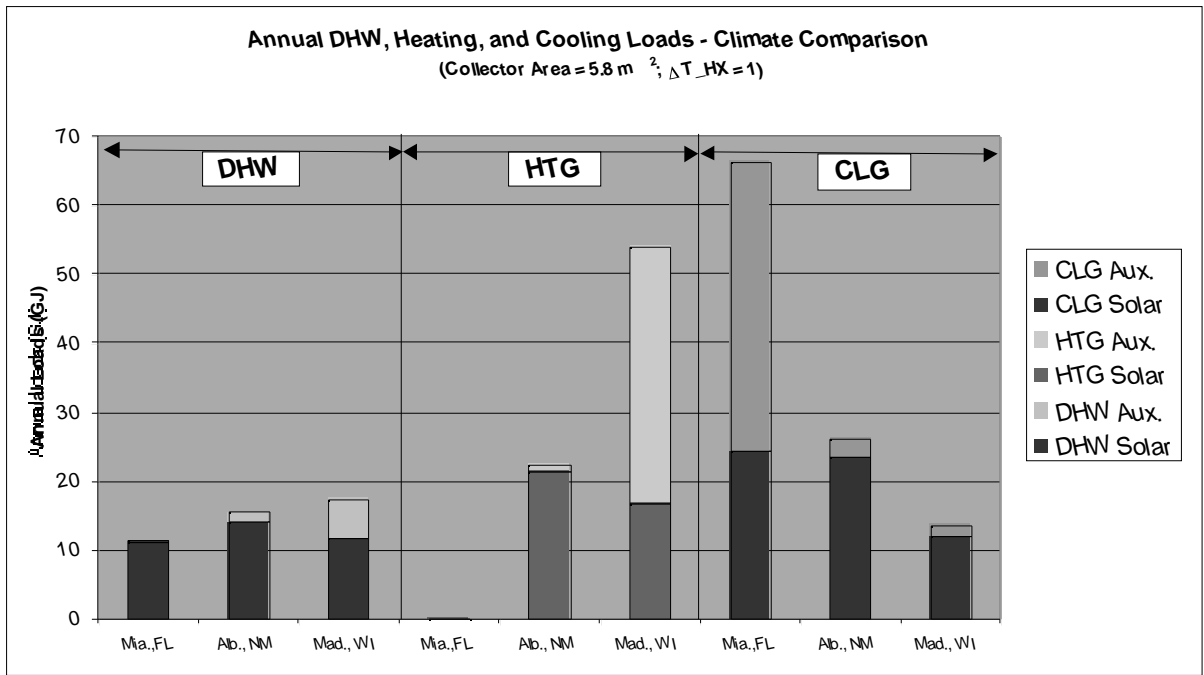


Figure 3. Domestic hot water (DHW), Heating (HTG), and Cooling (CLG) performance of the multi-use unglazed system in three climates. DHW bars have horizontal lines, HTG bars have vertical lines, and CLG have cross-hatched lines. Dark backgrounds are load met by the solar system, and light backgrounds are auxiliary energy. Collector area is largest simulated, at 93 m<sup>2</sup>. Albuquerque meets ~92% of the total loads, as opposed to about 40% for Madison (large unmet heating load) and Miami (large unmet cooling load).

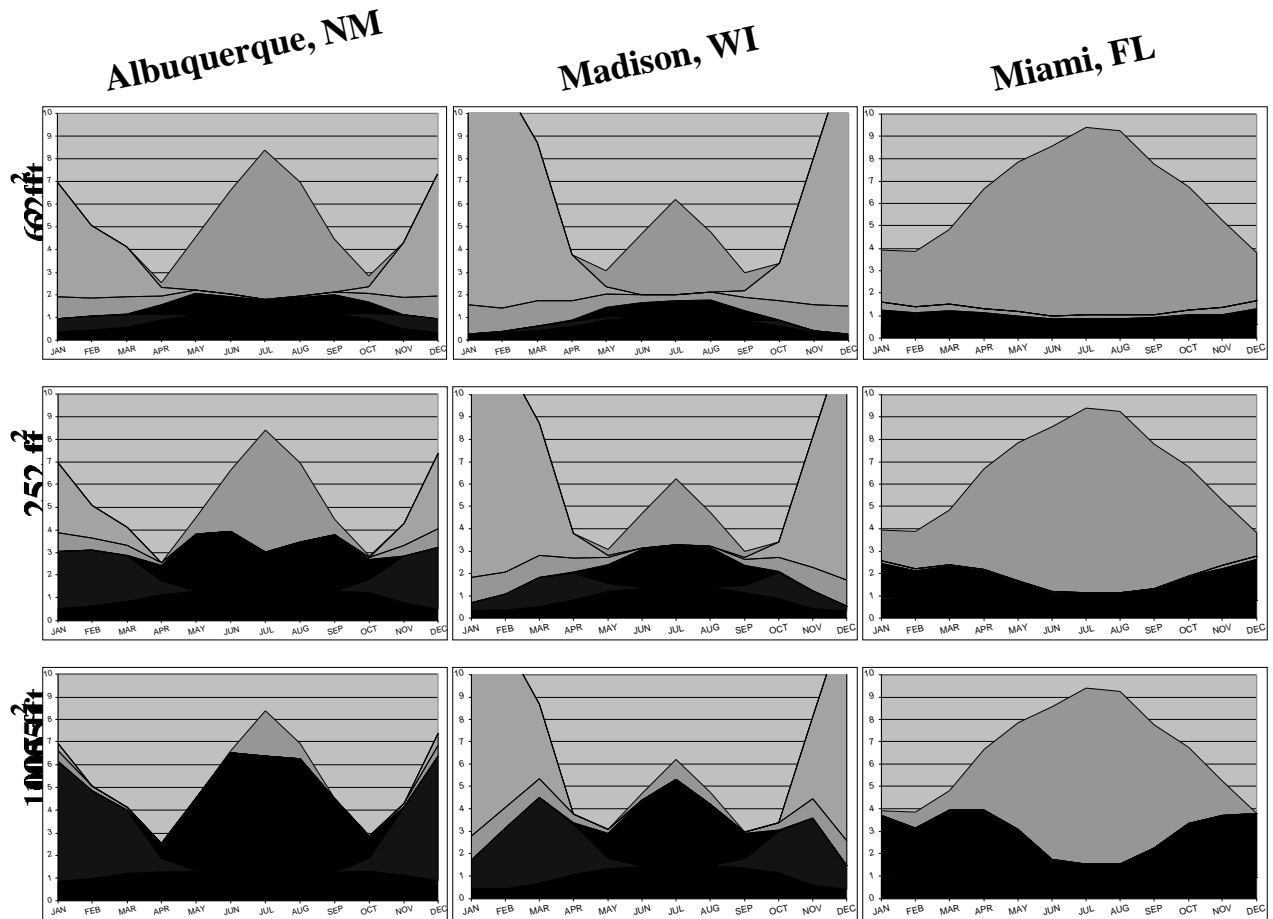


Figure 4. Stacked plots of the monthly water heating (DHW), space heating (HTG), and space cooling (CLG) performance of the multi-use unglazed system in same three climates at the same three collector sizes as Figs 1-3. The variable identification scheme is the same as in Figs 1-3: i) DHW has horizontal lines, HTG has vertical lines, and CLG has crossed lines; and ii) dark backgrounds are load met by the solar system, and light backgrounds are auxiliary energy. As in Figs 1-3,  $T_{hx}$  is set to 1C. In Albuquerque, most of the loads are met by the medium-sized or large-sized system. Cooling savings in Miami come primarily in the winter and swing months. Most of the cooling load is not met in Miami. Most of the heating load is not met in Madison.