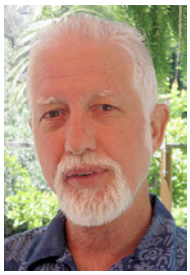
Very high efficiency evaporatively cooled mini-split AC condenser

Research at the Florida Solar Energy Center (FSEC) has developed and refined an evaporative cooled mini-split heat pump. The heavily instrumented mini-split heat was a 1.5-ton Fujitsu model (**Figure 1**) with a 5.62 W/W Seasonal Coefficient of Performance (COP) and a cooling capacity of 2.0 to 6.7 kW. The system has been tested for full summers in the lab and in a field test site.



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We demonstrated an innovative evaporative pre-cooling system that improved energy efficiency of a mini-split air conditioner by 21% seasonally in Florida's humid climate. **Further, the same apparatus was able to improve air conditioner efficiency by almost 50% at a peak condition of 35°C outdoors**. COP at this very hot condition was still 5.1 W/W. Average water consumption of the evaporator cooler was about 22 liters per day – a modest consumption given large improvements in air conditioning energy efficiency. With condensate water plumbed to the evaporative sump, estimated net water needs could be less than 4 L per day in humid climates and need to dump sump water is greatly reduced.

The pre-cooler assembly is inexpensive with few moving parts and could be manufactured as add-on or OEM kits for mini-split air conditioners. Estimated retail cost is €350 or less. The evaporative pre-cooler could improve seasonal cooling efficiency by 30–50% in most European climates (Lecce: 37%, Lisbon: 33%, Athens: 36%, Sevilla: 46% and Madrid: 50%) with dramatic improvements in peak cooling performance- desirable for capacity constrained utilities. Extensive test data is available in the full laboratory report and two units have been under long term evaluation. With no obvious prior art, patents have been filed.

There are two major competing evaporative cooling air conditioner technologies to that developed by FSEC. The two most prominent are *EvaporCool* in the U.S. (www.evaporcool.com) and the *EneCut* in Japan (http://bit.ly/18vtkra). Both systems use nozzles to mist water before the evaporator coil. While nozzles are effective for evaporative pre-cooling, they have several drawbacks as indicated below:

- Mist can be entrained into the air stream reaching the condensing coils, possibly fouling these and making AC manufacturers leery of honoring warranties
- Nozzles are prone to fouling, particularly with hard water supplies
- Variations in city water pressure can affect coverage
- Greater power is required for misting (our system uses a simple 4 W pump) and more sophisticated controls.
- The mist from the nozzles is prone to "drift" from wind which makes this largely impractical for residential AC units where the air flow into the condenser is at a relative low rate. *Misted drift from the nozzles can deface adjacent walls or create other maintenance issues.*

Figure 1. FSEC Evaporative Mini-split cooling system.

Unlike previous evaporative cooling concepts, the configuration is simple and robust. The FSEC concept has much greater potential reliability, no potential to create droplets that might harm the equipment or the home surroundings. We use sacrificial off the shelf and recyclable evaporative media that is replaced every four years. To expend pad life, we measure total dissolved solids continuously and dump sump water (–7 L) when TDS is greater than 1 500 ppm.

The rate of water consumption of the FSEC evaporative cooler is modest and can be effectively supplemented by using condensate water. **Figure 3** shows the condensate release and evaporative cooler water and use rates summarized over a 24-hour period. This shows that, evaporative cooler water use is higher in the daytime hours and lower at night than the condensate release. Evaluating more closely, on average, a condensate collection sump that was 4.2 liters larger in capacity than pump inlet point, would result in best utilization of daily condensate water use for the evaporative cooler.

Offering 30–50% efficiency improvement and modest water use, the evaporative cooling concept is particularly attractive with multi-splits where lower overall efficiency is overcome by large improvements in single condensers. Electric utilities will be interested in the technology since peak summer cooling power is reliably reduced by 50% or more even in humid climate. ■

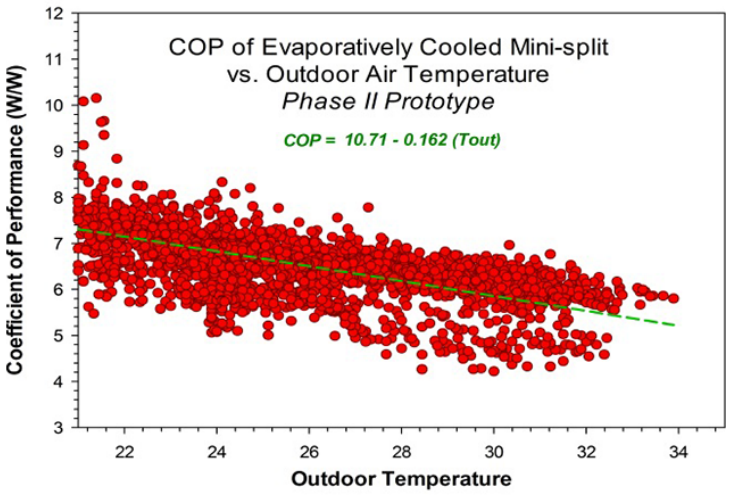

Figure 2. Measured COP vs. outdoor temp.

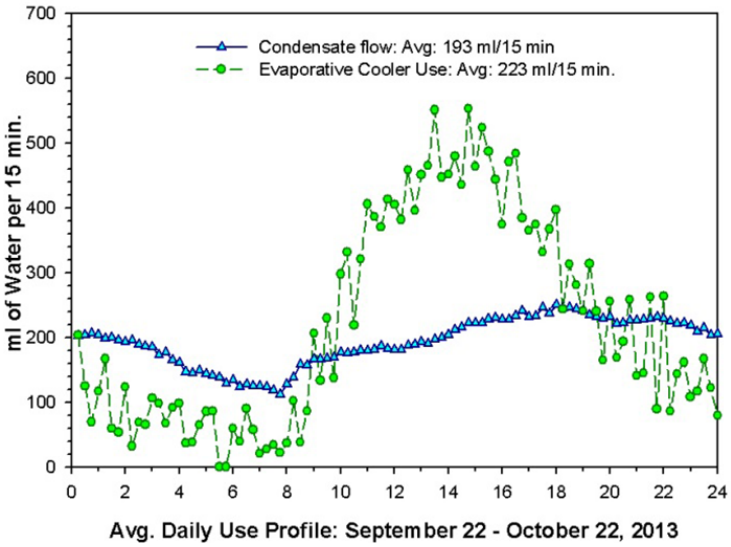

Figure 3. Evap cooler water use v. condensate release.