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Dew Point Evaporative Comfort Cooling

Indirect Evaporative Coolers Delivered 50-90% Energy Savings

Over the course of three years, the National Renewable Energy Laboratory tested 24 IECs from Coolerado Inc. at Fort Carson Army Base in Colorado Springs, CO.

EVAPORATES WATER WITHOUT ADDING HUMIDITY

Indirect evaporative coolers (IEC) use a unique air processing technology that removes heat and moisture from outside air, while conserving between 50% and 90% of the energy typically consumed by mechanical air conditioners.

63% ENERGY SAVINGS, MAINTAINED THERMAL COMFORT

The ESTCP demonstration found average energy savings of 63% and that 99% of ASHRAE comfort zone requirements were met. The evaluation also revealed an increase in water use in comparison to air-cooled rooftop unit (RTU)s. IECs will be most cost-effective for data centers in dry climates, where payback can be as low as three years when compared to a code-compliant RTU.

Technology Tested

INDIRECT EVAPORATIVE COOLER (IEC)

- Air filters and a heat mass exchanger remove heat and moisture from outside air.
- Accumulated moisture is exhausted at each filter stage, enabling up to 30% colder supply air-temperature (SATs) than traditional direct evaporative coolers.
- Efficiency increases as outdoor temperatures rise.
- 90–120% wet bulb effectiveness.
- Eliminates chemical refrigerants used in conventional air-conditioning.
- Most common application is as a through-the-wall or roof-mounted zone cooler.

Best suited to:

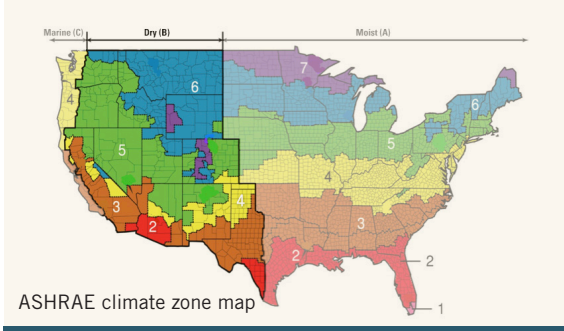
- Facilities in dry climates—ASHRAE zone subtype B.
- Single zone dedicated outside air system in climate zone 2B-6B.
- Outside pre-conditioner for zones 2B and 3B.
- Zone cooler for zones 4B, 5B and 6B.
- Facilities with high internal loads and/or high ventilation rates that require year-round cooling, such as data centers.
- Best economics for new construction and when competing against smaller air-conditioning systems with Energy Efficiency Ratios (EERs) of 8–12.
- Note: In climate zones 4B, 5B and 6B, the system needs to be shut down and winterized at the end of the cooling season.

Limitations:

- Not appropriate for ASHRAE zone subtype A. High outdoor humidity reduces cooling capacity and energy savings.
- Increased water use when compared to air-cooled RTUs.

ABOUT ESTCP

The Environmental Security Technology Certification Program (ESTCP) is the U.S. Department of Defense's environmental technology demonstration and validation program. The program's goal is to identify and assess innovative technologies that address DoD's high-priority environmental requirements efficiently and cost-effectively.



ASHRAE climate zone map

Demonstration Site: Fort Carson Army Base, CO

Twenty-four IEC units were installed in five commercial building types at Fort Carson Army Base. A stand-alone unit was also installed at a wastewater treatment plant to test the technology's ability to operate using gray water. Technology performance was modeled using the energy simulation software tools eQuest and EnergyPlus in three building types across six applicable climate zones—Phoenix, Arizona; Las Vegas, Nevada; Los Angeles, California; Albuquerque, New Mexico; Colorado Springs, Colorado; and Helena, Montana.

INSTALLED COSTS PER TON*

INDIRECT EVAPORATIVE COOLING

$4,000–$5,200

AVERAGE CODE-COMPLIANT RTU

$2,000
$2,600 (with add-on evaporative cooling)

*Cost information is for reference only. Individual sites should do due diligence to determine local costs.

LESSONS LEARNED

- IEC most cost-effective for new construction applications.
- Unit drainage water should be diverted or stored and used for irrigation to avoid potential safety hazards.
- Cycles of concentration (CoC) have a significant impact on water consumption. To reduce water usage, CoC should be set to 5 when inlet water has low calcium carbonate concentrations.
- Properly size units to achieve highest efficiency. Undersized units can lead to higher energy consumption.

Demonstration Results

ENERGY SAVINGS

- 63.3% annual energy savings compared to a code-compliant RTU. Simulations show savings between 57–92% across dry climates.
- Peak power < 1 kW/ton; average power < 0.6 kW/ton. Average seasonal efficiency 0.157 kW/ton; EER 76.4).

WATER USE

- Increased site water use compared to air-cooled RTUs (~3 gal/ton/hr with proper CoC set up).
- Use of gray water was not successful due to biological growth. Cleaner waste water such as that produced by rainwater harvesting could be used for future installations.

INSTALLATION

- Sufficient pressure relief is needed via pressure relief dampers, the exhaust air system or natural building exfiltration. (At Fort Carson, the buildings were older and had significant air leakage, so pressure relief dampers were not needed.)

OPERATIONS & MAINTENANCE

- Estimated to be $39/unit/yr more expensive than standard air-cooled RTU.
- Single facility technician can operate and maintain with minimal training.
- No degradation in wet bulb effectiveness over 3 years.

COMFORT

- Met ASHRAE comfort requirements for temperature/humidity >99% of the time.
- 80% of the units provided air <70°F. (Units with higher temperatures were due to inadequate water distribution in the heat mass exchanger (HMX), a defect that should be resolved with the latest version of technology.)

COST-EFFECTIVENESS

- 8–42 years payback for replacing an RTU at Fort Carson utility rate of $0.07/kWh. Buildings with 24-hr cooling loads offer best payback. Payback can be reduced to 3 years if equipment is at end-of-life and needs to be replaced.

Additional Resources

- **EW-200821 FINAL REPORTS AND TECHNOLOGY TRANSFER TOOLS**
  https://serdp-estcp.org/Program-Areas/Energy-and-Water/Energy/Conservation-and-Efficiency/EW-200821
- **TECHNOLOGY USED AT DEMONSTRATION SITE**
  Indirect Evaporative Cooler (IEC), www.coolerado.com.

NOTE: Before incorporating new technology, refer to Unified Facilities Criteria (UFCs) and other appropriate guidance to ensure compliance with current requirements. https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

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