General Services Administration
Public Buildings Service

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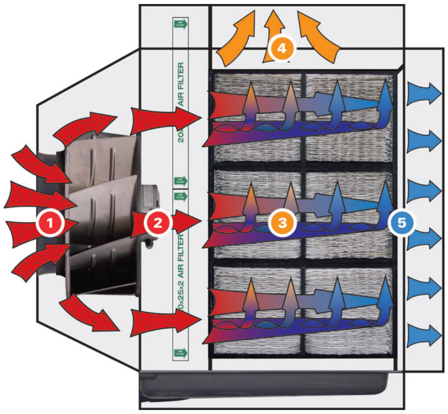
INDIRECT EVAPORATIVE COOLER

Multistaged Indirect Evaporative Cooling System Significantly Reduces Energy Use in Dry Climates

Air conditioning is the single largest contributor to peak demand on US electricity grids, as well as the primary cause of grid failures and blackouts.[1] This problem is compounded by the fact that conventional refrigeration-based air-conditioning units are least efficient at high ambient temperatures, when cooling demand is greatest. Multistaged indirect evaporative cooling (IEC) promises an energy-efficient alternative. Multistaged IEC uses a unique air-processing technology that removes heat and moisture from outside air and delivers space conditioning using only a fraction of the energy consumed by mechanical air conditioners. A previous National Renewable Energy Laboratory (NREL) study that modelled multistaged IEC energy savings demonstrated that, in dry climates, multistaged IEC systems have the potential to reduce energy use by between 57 and 92 percent,[2] when compared to standard air-cooled, refrigeration-based air-conditioning units. To verify the effectiveness of this technology, GSA's GPG program, Rocky Mountain Region, recently commissioned NREL to evaluate three multistaged IEC systems installed at the Denver Federal Center (DFC), in Lakewood, Colorado. Findings included an 80 percent reduction in energy consumption and an average simple payback for data centers of less than 15 years.

INTRODUCTION



Side view of the multistaged indirect evaporative cooler airflow process

1. 100% fresh air is drawn into the air conditioner by a fan
2. Air is filtered of dust and allergens
3. Working air removes heat
4. About half of the air that enters the system is saturated with water and exhausted
5. The other half of the cooled air enters the building with no added humidity

> *"The energy savings of this cooling technology are impressive and the units have helped to make the fitness center a more comfortable place."*
>
> —Charlie Rienhardt
> DFC Sustainability Program Manager
> GSA Rocky Mountain Region

PERFORMANCE SPECIFICATIONS Energy-Efficiency Ratio (EER)	
INCUMBENT	
Code-compliant RTU	**12**
MULTISTAGED IEC	
DOE Verified[3]	**40+**
NREL Weighted Average	**63**

What We Did

BROAD ASSESSMENT FOLLOWED INSTALLATION OF IEC UNITS

Over the course of three months in the summer of 2012, NREL monitored the performance of three multistaged IEC units installed in a fitness facility at the DFC. Denver was chosen because its high, dry climate provides an optimal performance environment for multistaged IEC technology. The objective was to assess energy use, water use, interior thermal comfort, and life cycle costs. All three IEC units were suspended from fitness facility rafters and configured to cool and deliver 100% outside air to select zones within the conditioned space. A local thermostat was installed and a central building automation system provided set point and scheduling for the entire system.

What We Measured

RESULTS COMPARED TO TYPICAL RTU

Energy savings potential and the multistaged IEC units' ability to maintain acceptable interior thermal comfort were central to the DFC evaluation. Supply air temperature, interior space temperature and interior relative humidity were monitored to ensure that the three IEC units supplied enough cold air to maintain acceptable thermal comfort as defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). The outside air temperature, outside air relative humidity, supply air temperature, and electrical energy use were used to calculate a weighted annual operational energy efficiency ratio (EER) and energy savings, which were then compared to those of a traditional rooftop unit (RTU) with an air cooled direct expansion (DX) cooling system. Water consumption was measured and compared with the regional water use associated with grid-purchased electricity, and since this facility was not air conditioned prior to the installation of the multistaged IEC units, the life cycle costs were compared with the estimated installed costs and energy performance of the traditional RTU.

FINDINGS

SIGNIFICANT ENERGY SAVINGS IN DRY CLIMATES The multistaged IEC achieved an 80% reduction in energy consumption when compared to a code compliant RTU with an EER of 12. This put energy savings well within the range of the modelled multistaged IEC energy savings in the previous NREL study.[2]

LIFE CYCLE COST-EFFECTIVE The simple payback period at the site was 22.8 years and the system was life cycle cost-effective over a 40-year project lifetime. Because this technology works best in climate zones that have relatively few cooling-degree days, more favorable payback can be achieved in facilities with increased operational hours, such as data centers, where the average payback was less than 15 years.

COMFORTABLE INTERIOR SPACE CONDITIONS During operating hours throughout the monitoring period, the multistaged IEC units were able to maintain comfortable space conditions, as defined by ASHRAE.

THREE TARGET MARKETS OFFER FAVORABLE ECONOMICS Three target market segments have been identified for this technology: data center installations in ASHRAE climate zones 2B through 6B; outside air pre-conditioner retrofits for air-cooled RTUs in climate zones 2B and 3B; and new construction and facilities that do not currently have cooling systems in climate zones 4B, 5B, and 6B. In ASHRAE climate zones 1A through 7A, the increased outdoor humidity characteristic of these zones reduces cooling capacity and overall energy savings to the point that the multistaged IEC will not provide a favorable return on investment.

Target Markets Favor Dry Climate Zones (Subtype B)

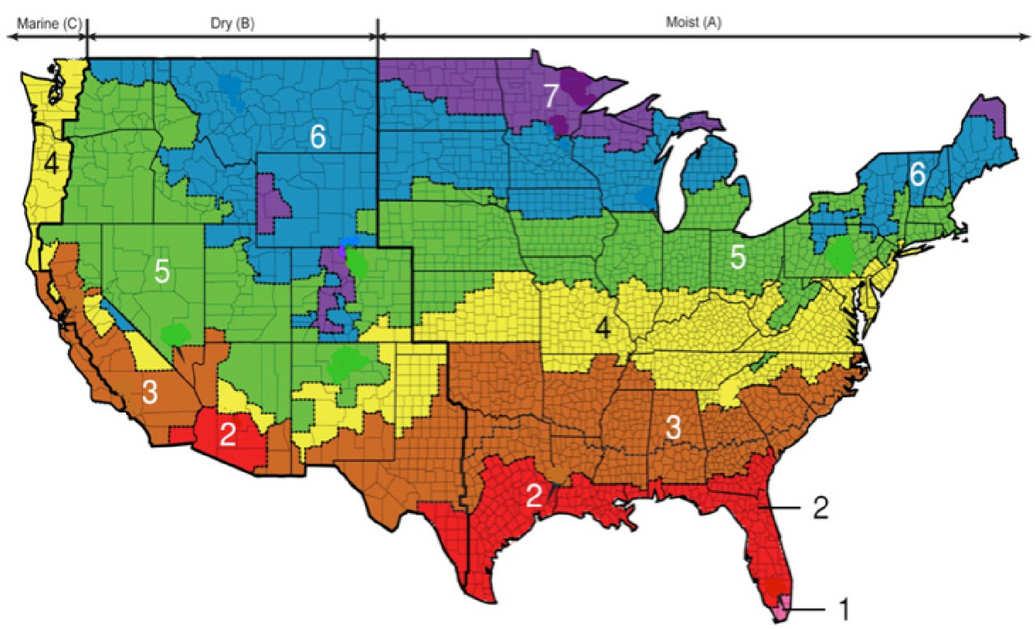
Data centers in ASHRAE climate zones 2B – 6B are top target market

TOP 3 TARGET MARKETS

Data Centers
2B – 6B
Retrofit & New Construction

Outside Air Pre-Conditioner
2B, 3B
Retrofit onto RTUs with EER ≤ 12

Zone Cooler
4B – 6B
Retrofit & New Construction



CONCLUSIONS

These Findings are based on the report, "Multistaged Indirect Evaporative Cooler Evaluation," which is available from the GPG program website, www.gsa.gov/gpg

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What We Concluded

MULTISTAGED IEC REDUCES ENERGY USE WHILE MAINTAINING THERMAL COMFORT

The multistaged IEC achieved an 80% reduction in energy consumption when compared to a typical RTU, and was life cycle cost-effective over a 40-year project lifetime. It would not have been cost-effective, however, if the facility had had existing air conditioning: without incremental payback, energy savings would not have equaled capital costs within the project's lifetime. Also, although the technology reduced energy use and maintained thermal comfort, it increased site water consumption by 19,956 gallons per year. The increase, however, was offset by the reduction in energy provided by a local, thermally driven power plant, which consumes water to produce electricity. For this reason, the multistaged IEC did not increase overall regional water consumption.

Lessons Learned

ANNUAL COMMISSIONING IS CRITICAL TO PROPER OPERATION

Performance problems discovered shortly after the three multistaged IEC units were installed at the DFC confirmed that proper commissioning of the technology is critical. When units are started up, facility personnel should ensure that all settings are correct, that waterside solenoid valves are working properly, and that all units are providing sufficient cooling. They should also measure water use and outside air conditions. To ensure proper operation over the life of the technology, a thorough inspection should be performed annually.

Footnotes

[1]Heat Wave Nearly Causes Rolling Blackouts in California, http://www.nytimes.com/2000/08/02/us/heat-wave-nearly-causes-rolling-blackouts-in-california.html

[2]Dean, J.; Herrmann, L.; Kozubal, E.; Geiger, J.; Eastment, M.; Slayzak, S. (2012). Dew Point Evaporative Comfort Cooling: Report and Summary Report. 198 pp.; Summary Report: 40 pp.; NREL Report No. TP-7A40-56256.

[3]Coolerado Product Brochures 2014: M30, M50 and C60

Cover Photo Credit: GSA

Technology for test-bed measurement and verification provided by Coolerado.