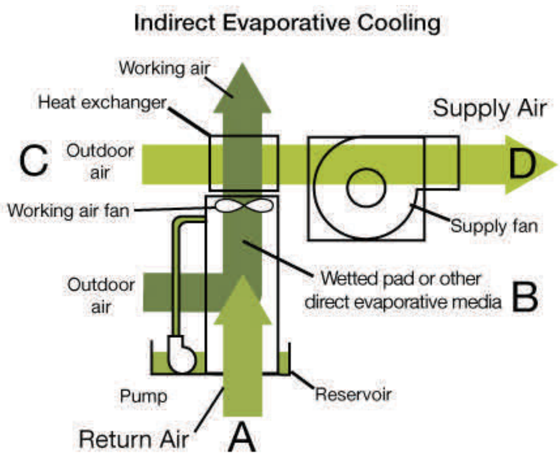
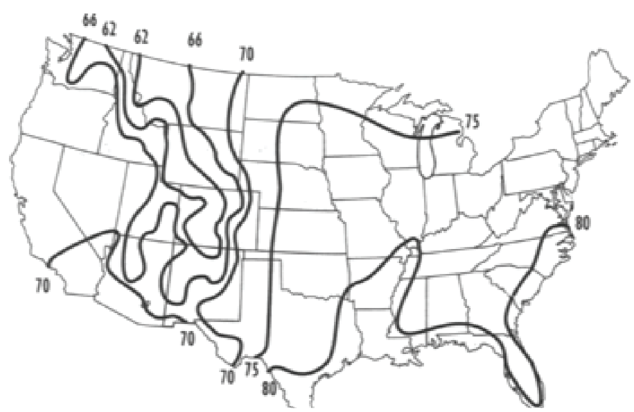
Indirect Evaporative Cooling

With Zero Net Energy1 (ZNE) a growing building design and energy policy trend, design firms and owners are striving to meet heating, ventilation and air conditioning (HVAC) loads with optimum comfort and minimal energy. Indirect Evaporative Cooling (IEC) offers a highly efficient way to cool an indoor space without raising the humidity. Today's indirect evaporative coolers use only a fraction of the energy of typical HVAC systems.

Cooling accounts for 15% of the electricity in California office buildings and up to 30% of peak electric demand. IEC can be combined with, or in some cases replace, traditional or advanced cooling systems to significantly reduce cooling energy use. IEC is available for a wide range of building types including office, school, retail, industrial, and warehouse, as well as residential buildings of all sizes.

Evaporative cooling methods were around long before the advent of mechanically based cooling and can be found in traditional architecture in hot and dry climates around the globe. This direct evaporative cooling (DEC) passes air over or through a wetted medium, to cool the air through evaporation, which adds the evaporated moisture to the air as the air's temperature moves toward its dew point. With traditional DEC, this cool, moist air is blown into the building spaces. IEC does not blow evaporatively cooled air into building spaces. Instead, it passes DEC air through a heat exchanger to cool a separate IEC stream of air that is blown into building spaces. The IEC air is cooled without increasing its moisture, which avoids a build up of humidity in the building. This supply air can include both recirculated return air and fresh outside ventilation air. IEC expands the inherent cooling efficiency of the evaporative process to use evaporative methods "indirectly'" to avoid the introduction of added humidity and to combine these systems with traditional, compressor-based HVAC. IEC can also be effectively used in buildings with cooling towers.



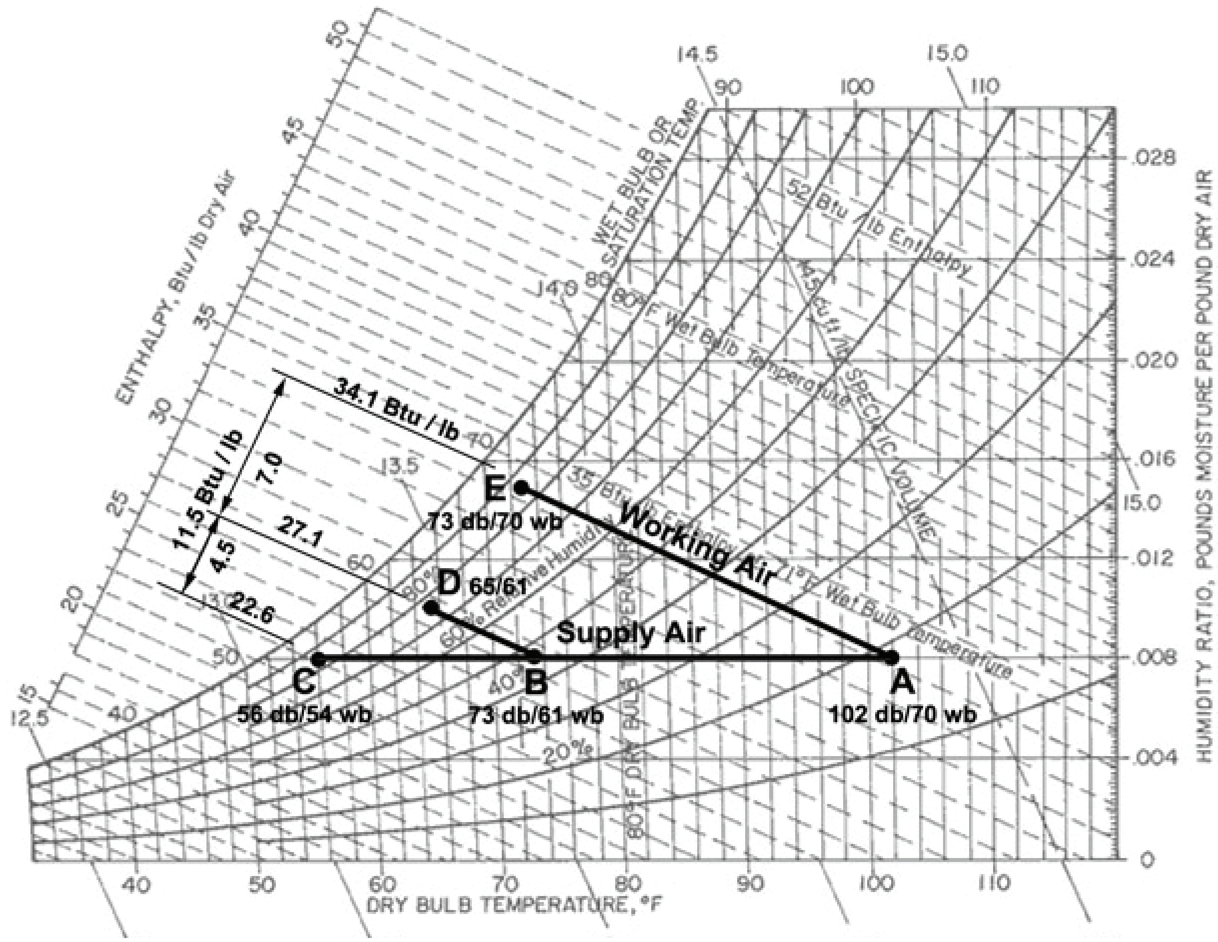


In the figure return air (A) from the space and outdoor air pass directly over a wetted medium (B) to passively remove sensible heat through DEC and then pass through the heat exchanger and is discharged. Outdoor air (C) enters as a supply air stream, passes through the heat exchanger and is 'indirectly' evaporatively cooled before being delivered to the space (D). Compressor-based equipment can be stage-2 cooling following D.

Effectiveness of evaporative cooling, both DEC and IEC, depends on the difference between outside air temperature and its dew point. The higher the difference, the greater is the cooling potential. (In more technical terms, dew point = web bulb temperature = wb which is the temperature measured by a thermometer with a wet wick around its bulb. The normal temperature measurement of a thermometer (which has no wet wick) = dry bulb temperature = db. EC effectiveness (EF) is simply described by EF = (db – SAT) / (db – wb), where SAT = supply air temperature. The desired SAT is generally the same everywhere, so effectiveness is primarily dependent on wb = dew point. The map shows lines of equal wb in F = Fahrenheit which are not exceeded more than 1% of the time during the cooling season. Evaporative cooling is particularly effective in regions with wb = 70F or below and can be comfortable for many people up to 75F, which describes most of the western half of the United States, most of Australia and Middle East, Mexico, Africa, and much of South America. Particularly notable, as outdoor temperatures increase, the efficiency of conventional HVAC systems decreases while evaporative-based systems become more efficient

The psychometric chart shows example conditions for Phoenix, AZ with outdoor temperature 102db and dew point 70wb. Line AB shows DEC can cool air to 73db, with same dew point 70wb, with relative humidity = RH = 90%, which is cool, wet supply air if blown into the building space. If this air is used as working air to cool separate supply air, Line AB shows the supply air temperature if the DEC air is used for IEC, producing SA = 73 db and 61 wb, cool, dry air for building space. Line BC shows that if the IEC supply air is used as input air to conventional HVAC, supply air to building space is 56db and 54 wb, still cooler, dryer supply air. Alternatively if supply air at point B is itself passed through a separate DEC, it can provide 65db, 61 wb air to the building space. Reducing HVAC capacities significantly reduces peak electrical demands caused by hot weather cooling.

Air enthalpy = H = energy (Btu / lb Dry Air) is shown by left sloped line values for left to right down lines, and its value is determined by its wb. Outdoor air, at A has H = 34.1. DEC from A to E evaporates moisture and cools the air without changing its energy, because it exchanges decrease energy in the air's temperature to increased energy in the airs moisture. IEC from A to B uses the lowered temperature of the working air to cool supply air, which decreases supply air energy, but with no increase in supply air moisture. Hence, the energy in supply air is decreased with no cost in energy. Therefore, IEC requires no input of energy to cool outside air. If further cooling is desired, the IED supply air can be input to conventional air conditioning for further cooling, such as to point C (58 db/54 wb), which requires energy input of 4.5 BUT / lb dry air. Or it can be passed through an additional DEC, which cools it by adding moisture, such as to point D (65 db/61 wb) with no additional energy input. Using conventional air conditioning to cool outside air from A to B requires 7.0 Btu/lb dry air, all of which is saved if IEC is used. Cooling air conventionally from A to C requires 11.5 BTU/lb dry air, of which 7.0 is saved using IEC, a saving of 61% of energy.



Recently modeled savings potential for IEC in an October 2014 New Building Institute report are shown in the table below. Indicated savings are in line with tests on retrofits of buildings with existing systems.

Modeled Percent Energy Use Reduction for Indirect Evaporative Cooling

Location	Classrooms	Data Center	Quick Serve Restaurants
Phoenix, AZ	65%	77%	70%
Las Vegas, NV	68%	76%	
Los Angeles, CA	63%	81%	
Albuquerque, NM	66%	86%	
Colorado Springs, CO	64%	88%	57%
Helena, MT	65%	92%	