Take aways – Three points

• Use and application of, IEC/DEC + DX – even in some applications not necessarily of typical acceptance

• Efficiency of using IDEC

• H₂O use vs drought
EPX is Best Applied in the Dry Western States
DIRECT EVAPORATIVE COOLING ... A CONSTANT WET BULB PROCESS

HUMIDIFIES AND COOLS
Additional Benefits of Evap Cooling with Media

• Sound Attenuation – Notable noise level reduction even in lower frequencies.
• Humidity control in arid regions
Indirect Evaporative Cooling = IEC or IDEC

- Not a new technology
- First recorded use was in the thirties and used cooling tower and coils
- First use with the Integral Heat Exchanger/Cooling Tower was in 1975 and it was then that the term “Indirect Evaporative Cooling” was coined
- From 1975 to 1985 IEC was used but a lot of projects failed because of poor designs
Indirect Evaporative Cooler (IEC) Cooling Tower Analogy

Cooling Tower to Cooling Coil IEC
Heat Load enters water loop and is rejected at CT

EPX Indirect Evaporative Cooler
Heat Load enters water and air directly within CT
IEC WITH GLASDEK MEDIA IN THE R/A STREAM BEFORE THE HEAT EXCHANGER

R/A @ 75/50% → DEC

S/A
81.9°F/65.7°F

HEAT EXCHANGER

63.5°F/62.2°F

O/A
100°F/69°F

E/A
IEC WITH DIRECT SPRAYS IN THE R/A STREAM

S/A
73.8°F/63°F

O/A
100°F/69°F

R/A @ 75/50%

E/A

WATER SPRAYS

HEAT EXCHANGER
Wet Bulb Depression Efficiency (WBDE)

Effectiveness = 100% x \( \frac{(EDBT-LDBT)}{(EDBT-WBT)} \)

- **EDBT** = Entering dry bulb temperature of primary air
- **LDBT** = Leaving dry bulb temperature of primary air
- **WBT** = Entering wet bulb temperature of secondary air

This example: \( \frac{(100-73.8)}{(100-62)} = 69\% \)

**IEC WITH DIRECT SPRAYS**
**IN THE R/A STREAM**

- **S/A**
  - 73.8°F/63°F
- **O/A**
  - 100°F/69°F
- **R/A**
  - 75°F/62°F

**Munters**
PSYCHROMETRIC CHART
2200 FEET
Barometric Pressure - 27.618 Inches HG
IEC VS DRY HEAT RECOVERY
10,000 CFM
LAS VEGAS WEATHER CONDITION
HEAT RECOVERY - 60% EFF
IEC - 70% WBDE

PSYCHROMETRIC CHART
2200 FEET
Barometric Pressure - 27.618 Inches HG
### Sample EER Calculation

<table>
<thead>
<tr>
<th>CFM</th>
<th>10000</th>
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<tbody>
<tr>
<td>Mass flow rate (lb/min)</td>
<td>638.56</td>
</tr>
<tr>
<td>IEC EAT</td>
<td>108</td>
</tr>
<tr>
<td>R/A WB</td>
<td>62.5</td>
</tr>
<tr>
<td>WBDE</td>
<td>0.7</td>
</tr>
<tr>
<td>HP LAT (deg F)</td>
<td>76.15</td>
</tr>
<tr>
<td>dt</td>
<td>31.85</td>
</tr>
<tr>
<td><strong>IEC cooling (btu/hr) =</strong></td>
<td>297750.3</td>
</tr>
</tbody>
</table>

| **Net Total Cooling Capacity (btu/hr)** | 297,750 |

| IEC Pump HP | 1 |
| IEC Pump KW | 0.7457 |
| Supply air pressure drop from IEC | 0.6 |
| Supply fan BHP contribution from IEC | 1.31 |
| Supply fan motor eff | 0.9 |
| Supply fan KW contribution | 1.09 |
| Exhaust air pressure drop from IEC (wet side) | 0.5 |
| Exhaust fan BHP contribution from IEC | 1.21 |
| Exhaust fan motor eff | 0.9 |
| Exhaust fan KW contribution from IEC+Condenser | 1.00 |

| **Total Electric input to achieve cooling effect (KW)** | 2.83 |

| **EER** | 105.0 |
Indirect Evaporative Cooling with Direct Spray Polymer Tubes (EPX)
Evaporative Polymer eXchanger

EPX

- 70% approach to exhaust WB
- 50% winter heat recovery

Flexible Polymer Tube
6 ft long

Munters
Dry, Cool Supply Air
(Air is “Indirect Evaporatively Cooled” since no water is added to supply air)

Hot outside air
(or building exhaust)

Polymer Tube HX

70.5°F/112gr

68.8°F/41.8gr

93°F/41.8gr

75°F/63.1gr

Pump

Water in Stainless Steel Welded Sump

70.5°F/112gr

Polymer Tube HX
Air enters HX tubes for dry cooling. Wet air leaves HX after extracting heat from the air inside the tubes. Air flowing inside the tubes is sensibly cooled by the evaporating water film on the tube exterior. Scavenger air flows up and around outside of the tubes while water flows down. Air enters HX tubes for dry cooling.
Munters EPX® Indirect Evaporative Heat Exchanger
Intertek/ETL Certified

The performance tests were conducted in accordance with the following standards:

Wet building exhaust or scavenger outdoor air leaves system, having extracted heat from air flowing inside tubes.

Air to be cooled flows inside Polymer tubes.
Mist Eliminator Media installed above HX
This photo shows scaling resulting from operating a unit with zero bleed water and no water treatment in Las Vegas. Note that even with these harsh conditions, the scaling was limited and had no adverse impact on IEC performance.
Ways to Apply Indirect Evaporative Cooling

- Outdoor Air Pre-cooler (Pre-cool air feeding other AHUs)

- Outdoor Air Pre-cool + Pre-heat (Uses building exhaust to provide summer indirect evaporative cooling + winter heat recovery)

- Total AC with or without building Exhaust
  (indirect evaporative with options for direct evaporative and/or DX cooling)
EPX Preconditioner

- AHU-1
- AHU-2
- AHU-3
Cooling System Comparison

- 353,600 cfm at 105 °F/74 °F WB to 83.3 °F/67.7 °F
- IEC Total Tons of Cooling = (353,600 cfm)(105-83.3)(1.1)/12,000 = 703.37 Tons (sensible)
- Total KW IEC at 0.2 KW/ton = 140.67 KW
- Total KW Aircooled Chiller at 1.2 KW/ton = 843.6 KW
- Total KW peak day demand reduction = 702.93 KW
- Total KW peak day demand reduction using IEC and DEC = 1107.9 KW
- Additional savings achieved from lower capital first cost from distribution piping, refrigerant, electrical feeds, maintenance.
In August 2011, a test was run on the IEC-3 module at the California Office of State Publishing. Ambient temperatures at 2:00 p.m. were 95.5°F DB and 68.5°F WB. The IEC unit was cooling the outdoor air, leaving the dry-side polymer tubes down to 74.1°DB and 61.5°F WB. This represents an approach to the ambient WB condition of 79.26%, 11% above the specified performance requirements with full flow through both sides of the air-to-air heat exchanger.

The dry side flow through the heat exchanger was 98,200 cfm constant volume. The sensible cooling produced was calculated to be 192.6 tons. Assuming an 80% saturation efficiency for the air washers located downstream of the IEC module, the supply air to the building would be in the range 64°F DB, ignoring fan heat.
- 53,000 cfm unit in a single piece with no splits
- No field assembly required

Example layout, RA energy recovery & scavenger OA option
EX: Whole Building Comfort Cooling w IDEC
• Up to 70%+ WBDE and Winter Heat Recovery with 50% Effectiveness
• EER in excess of 100 possible
• Corrosion resistant: works great for labs, pools and other corrosive airstreams
• The polymer heat exchanger self cleans. Proven performance for operational concerns related to hard water, arid conditions.
Why do we need Direct Evaporative Cooling?
PSYCHROMETRIC CHART
5700 FEET
Barometric Pressure - 24.251 Inches HG

WITHOUT DEC, WE WILL NEED 18.7 TONS OF REFRIGERATION COOLING TO GET TO SUPPLY TEMPERATURE

18.7 TONS

55F DEW POINT LINE

55F/43.1F
52.4F/50.2F

Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com
Combining IEC and DEC- IDEC Systems

- DEC downstream of the IEC
- IEC provides a new lower wet bulb for DEC allowing for further cooling without too much penalty of humidity addition
PSYCHROMETRIC CHART
2200 FEET
Barometric Pressure - 27.618 Inches HG

* 2 Stage 100% O/A IEC/DEC system requires less refrigeration than 100% recirculation system
* Provides better IAQ while reducing energy consumption

Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com
How Outdoor Air May be Used to Dehumidify Natatoriums

Typical Western City DB Design

dp = 68.6°F

dp = 63.4°F

60°F dp

85/65
In Summer, Most Indoor Pools May be Cooled With 70°F to 75°F Supply Air. This can be achieved with Direct Evaporative Cooling in Most of the West WHILE Also Controlling Humidity.
Direct Evaporative Cooling Indoor Pools
Face & Bypass is the Key to Control

Room Effect

74.5/67

TYP WESTERN US CITY
DB Design
Benefits of Applying Direct Evaporative Cooling To The Design of Natatorium Air Handling Systems:

1. Energy Savings: No compressors PLUS better humidity control results in lower pool water evaporation and resulting costs of water heating (DX cooling systems with min OSA in dry climates can result in over drying of the space)

2. Improved IAQ, resulting from higher ventilation rates when cooling is required

3. Direct evaporative cooling provides air washing that removes some pollen and other particulate
Direct Evap Cooling in Pool Application

Rio Rancho Aquatic
Rio Rancho, NM
30,000 CFM
100% O/A capable
Direct evap. cooling
E/A energy recovery
Indirect Evap Cooling in Pool Application

Radisson Water Park
Albuquerque, NM
42,000 CFM
100% O/A capable
Indirect evap. cooling
E/A energy recovery
Triple Dip System
THE TRIPLE DIP SYSTEM ...
IEC, DEC, & EVAP COOLED CONDENSER
IEC VS CONVENTIONAL SYSTEM
10,000 CFM

Lower condenser rejection temperature means less compressor work and higher COP for IEC system

IEC SYSTEM REJECTS CONDENSER HEAT TO THIS TEMPERATURE

CONVENTIONAL SYSTEM REJECTS CONDENSER HEAT TO THIS TEMPERATURE
Unit Tag: EC-1 (S/O# 66878)

**Major Components:**
A. DCT Horizontal Tube Heat Exchanger
B. DEC Media
C. S/A Fan with Motor and Drives
D. E/A Fan with Motor (Direct Drive)
E. DEC Motor Variable Frequency Drive
F. O/A Hood Filter Bank (Metallic)
G. S/A Filter Bank (30% Pleated)
H. S/A Filter Bank (85% Pleated)
I. Filter Cage / Switch (Typical)
J. O/A Face and Bypass Air Damper
K. DEC Face and Bypass Air Damper
L. Recirculation Air Damper
M. E/A Backdraft Damper
N. Cooling Coil (Direct Expansion)
O. Heating Coil (Hot Water)
P. O/A Hood with Birdscreen
Q. Unit Access Door (Typical)
R. Unit Access Panel (11'-0"CAL)
S. Condensing Section (Air Odd Fit)
T. Unit Electrical Panel
U. DEC Control Panel
V. Vapo Prog Soft (Typical)
W. GFCI Receptacle
X. Light Switch
Y. DriDek Mist Eliminator

**Notes:**
1. Minimum 3"-0" Clearance required for service access (coils may require more access for removal).
2. For drains and connections locations, size, and quantity see 5/18/99 - A-A02.
3. For base frame DWG see 57858-M-AA03.
4. For roof curb DWG see 57688-M-AA04.
5. For refrigerant pipe see 57688-M-AA05.
6. For DEC piping see 57688-M-AA06.
7. For IEC piping see 57688-M-AA07.
8. Unit overall envelope dimensions are shown in boxed dimensions.
9. Weather hoods may be shipped in pieces for assembly and installation by others.
10. E/A Fans to be shipped loose for assembly and installation by others.
11. Attenuation of fan sound power levels, if required, is by others.

**Air Flow Key:**
- O/A: Outside Air
- S/A: Supply Air
- R/A: Return Air
- E/A: Exhaust Air

**Order No.: 57868**
**Munters**

**Order Name: West College Utilities Facility**

<table>
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<tr>
<th>Drawing</th>
<th>Title</th>
<th>DWG.</th>
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**Sheet 1 of 1**

Submittal 57868 (EC-1) West College Utilities Facility, Rev-E

6 of 40
HIGH WATER CONSUMPTION WITH IDEC SYSTEMS???
• Evaporation of 1 pound of water requires 1,000 BTU of heat
• To provide one ton of cooling, we need to remove 12,000btu/hr
• 1 ton of cooling requires 12lbs/hr of water consumption

**Indirect Evaporative Cooler**

Water Evaporation = 12 Lbs/hr =1.44 gallons/hr per ton of cooling

**Cooling Tower**

Chiller adds about 3,000 btu/hr of parasitic load for every 12,000 btu/hr of cooling (approx 25%)

Water Evaporation = 15 Lbs/hr =1.8 gallons/hr per ton of cooling

• Additional water is wasted in CT due to drift.
• Bleed rate is higher due to higher evaporation rate and low cycles of concentration
2 gallons of water is required for every kWh of electrical power consumed

**Chiller**
- Efficiency of chiller is 0.8kW/ton
- 1 ton of cooling provided by chiller requires **1.6 gallons/hr** at the power plant

**IEC**
- Efficiency of IEC is 0.2kW/ton
- 1 ton of cooling provided by IEC requires **0.4 gallons/hr** at the power plant
IEC = 1.44 gal/hr through evaporation + 0.4 gal/hr at power plant

1.84 GALLONS/HR per ton

CHILLER/CT = 1.8gal/hr through evaporation + 1.6 gal/hr at power plant

3.4 GALLONS/HR per ton
Water-use efficiency for alternative cooling technologies in arid climates

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- Indirect evaporative cooling
- Water-use efficiency
- Water consumption
- Energy water relationship
- Cooling technologies
- Arid climates

ABSTRACT

In arid climates, evaporative cooling technologies are generally valued for their reduced energy consumption in comparison to compressor-based air conditioning systems. However, two concerns that are often raised with respect to evaporative cooling equipment are their on-site water use and the impact of poor water quality on their performance. While compressor-based systems do not use water on-site, they do consume water through their use of electricity, which consumes water through evaporation at hydroelectric power plants and cooling at thermal power plants. This paper defines a water-use efficiency metric and a methodology for assessing the water use of various cooling technologies. The water-use efficiencies of several example cooling technologies are compared, including direct evaporative, indirect evaporative in two different configurations, compressor-based systems, compressor-based systems with evaporative pre-cooling of condenser inlet air, and hybrid systems that consist of an indirect evaporative module combined with a compressor-based module. Designing cooling systems for arid climates is entwined in the close relationship between water and energy and the scarcity of both resources. The analyses presented in this paper suggest that evaporative systems that significantly reduce peak electricity demand and annual energy consumption need not consume any more water than conventional systems.

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Technical efforts should continue to improve water use efficiency for evaporative solutions; however:

Onsite consumption partially offset by water savings for reduced generation:
- Recent evaluations of various technologies show water use of 5-10 gal/kWh savings
- California average water use for electricity generation is ~1.4 gal/kWh
  - Thermal generation estimated at <1 gal/kWh
  - Hydroelectric generation estimated >10 gal/kWh
  - Water use intensity for generation varies widely by region

Estimate of water costs amount to 1-10% of the value of energy savings (not counting demand charges), depending on region, technology, and application.
If all commercial buildings in California used indirect evaporative cooling:

- Annual electricity savings = 6,511 GWh
- GHG emissions reduced = 4.5 MTonCO$_2$e
  - Equivalent to 950,000 automobiles
- Annual water use = 0.18 Million Acre Feet
  - 0.5% of all (non environmental) applied water use in California
  - Equivalent to 5% of all urban landscape uses
The research reported herein directly supports California Energy Efficiency Strategic Plan goals to accelerate marketplace penetration of climate appropriate air conditioning technologies. The report presents results from a field assessment of a dedicated outdoor air supply (DOAS) air handler that uses both indirect evaporative cooling and vapor compression to cool ventilation air for commercial buildings. This hybrid system was installed for an existing food store in San Ramon, California in combination with a whole building systems controls revision, and a closed door medium temperature refrigerated case lineup. In the year since installation, the project has demonstrated 20% whole building peak demand reduction, and 20% annual energy savings.
BENEFITS OF USING IDEC SYSTEM

- Energy Efficiency: Evaporative Cooling EERs in excess of 100 may be achieved.
- Can provide free cooling even if there is no building return air.
- Customers can achieve LEED points and can get utility rebates. Payback typically in less than 5 years.
- In arid climates, IDEC systems provide 100% O/A, leading to better IAQ while using less energy than typical recirculation air cooling systems.
- IDEC system helps reduce peak demand charges. They are most effective on the hottest days when most cooling is required.
- Positive impact on a regional basis for water use due to lowered kW use.
Three Take Aways

• Use, and application of, IDEC + DEC has a proven track record.

• When applied correctly, highly efficient and effective versus traditional mechanical cooling

• Don’t let water consumption be the sole deterrent – 3rd party verification supports the benefits of its use.
Questions
We’ve covered a LOT