INDIRECT DIRECT EVAPORATIVE AIR CONDITIONING

Darshi Dhaliwal - Low Energy Cooling Technologist
INTRODUCTION

- What is Indirect Evaporative air conditioning
- What makes IEC an attractive alternative
- Energy availability and cost
- Carbon Footprint
- Indian Climate
- New concepts & Designs
INDIRECT-DIRECT EVAPORATIVE AIR CONDITIONING

Indirect-Direct evaporative Air conditioning

1. Primary air stream is sensibly cooled first with indirect evaporative cooling using a one side wet, cross/counter flow heat exchanger.

2. The heat from the primary air is transferred to a small amount of ambient (scavenger) air

3. Primary air is cooled further with direct evaporative cooling.
WHAT MAKES IDAC ATTRACTIVE

- Using sensible cooling prior to adiabatic cooling further reduces the supply air temperature
- Comparatively less air quantity required than single stage system for same cooling effect
- No refrigeration used – environment friendly
- Reduces the power and water consumption by 50%
- No return air required – Improves the Indoor Air Quality (IAQ)
- VFD controlled fans
- Non corrosive structure
The power sector in India had an installed capacity of 272.38 Gigawatt (GW) as of March 2012. Thermal power plants constitute 66% of the installed capacity, hydroelectric about 19% and rest being a combination of wind, small hydro-plants, biomass, waste-to-electricity plants, and nuclear energy.

Nearly 53% of this is consumed by industry and commercial establishments.

Average power is around INR 6.5 and likely to touch INR 10.5 in the very near future.
DRY CLIMATE ZONES – AGE OLD SIMPLE DIRECT EVAPORATIVE COOLING
Can be expressed mathematically

- **Direct adiabatic cooling**:  

  \[ \text{DBT} - (\Delta\text{DBT}, \text{WBT}) \times \eta = \text{supply air} \]
INDIRECT DIRECT EVAPORATIVE COOLING PROCESS

Schematic
Can be expressed mathematically:

- **Sensible Cooling stage:**
  \[ \text{DBT} - (\Delta \text{DBT}, \text{WBT}) \times \eta = \text{DBT}_1 \]

- **Adiabatic Cooling stage:**
  \[ \text{DBT}_1 - (\Delta \text{DBT}_1, \text{WBT}_1) \times \eta = \text{supply air} \]
POLYMER PLATE HEAT EXCHANGERS

Stage 1

Moist Exhaust - Air

Wet plate cross flow heat exchanger

Inlet - Air

dry pre cooled Air

dry cooled secondary air

dry pre cooled secondary air

Sustainable Air Conditioning
EN³ POLYMER PLATE HEAT EXCHANGERS

© EN³ is the registered trade mark of Air Innovations India
EN^3 POLYMER PLATE HEAT EXCHANGER PERFORMANCE

![Graph showing supply air temperature vs. ambient temperature for different relative humidities.](image-url)
PSYCHROMETRIC CHART

SIMPLE EVAPORATIVE COOLING

INDIRECT DIRECT AIR CONDITIONER

Sustainable Air Conditioning
Sustainable Air Conditioning

ADDRESSING DIFFERENT CLIMATE ZONES

TYPE OF UNITS

1. **Hot Dry climates** zones of India can use Indirect Direct Evaporative Air Conditioning to replace conventional Air Conditioning.

2. **Warm & Humid** climate zones benefit by using Hybrid IDAC units.

3. **Composite** climate zones benefit by using either IDAC for summer only or Hybrid IDAC units.

4. **Moderate** climate zones can use Indirect Direct Evaporative Air Conditioning to ensure indoor comfort during mild summers.

5. **Cold** Zones can use them as a heat recovery unit.

ECBC CLIMATE ZONES

[Map of India showing different climate zones]
NEW CONCEPTS & DESIGNS

- Backward curve plug flow fans
- Direct Drive - No belts
- Blow Through Design
- No Secondary air fans
- PID Temp Controller Driven VFD
- PLC process control by Dedicated PLC
- Built in control panel
- All wet components in moulded FRP
- Universal air outlet
- Any level of filtration
NEW CONCEPTS - INDIRECT DIRECT EVAPORATIVE AIR CONDITIONING
Indirect Direct Evaporative Air Conditioning
Sustainable Air Conditioning
SOME APPLICATIONS

- Manufacturing facilities
- Malls
- Warehouses
- Religious Buildings
- Community & Marriage halls
- CNC machines Rooms
- 100% fresh air applications
- Cost effective replacement for evap. cooling
# DIFFERENTIAL PAYBACK PERIOD

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>Single Stage Summer</th>
<th>Two Stage Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiant Air Temp</td>
<td>DBT °C</td>
<td>41.8</td>
<td>41.8</td>
</tr>
<tr>
<td></td>
<td>WBT °C</td>
<td>23.6</td>
<td>23.6</td>
</tr>
<tr>
<td>Supply Air Temp</td>
<td>DBT °C</td>
<td>26.3</td>
<td>22.1</td>
</tr>
<tr>
<td></td>
<td>WBT °C</td>
<td>23.4</td>
<td>20.4</td>
</tr>
<tr>
<td>Room Temp</td>
<td>DBT °C</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Temp Difference</td>
<td>ΔT</td>
<td>3.7</td>
<td>7.9</td>
</tr>
<tr>
<td>Room Sensible Load</td>
<td>Tr</td>
<td>28.9</td>
<td>28.9</td>
</tr>
<tr>
<td>Air Quantity Required</td>
<td>CFM</td>
<td>48254.1</td>
<td>22600.0</td>
</tr>
<tr>
<td>Fan Power Consumption</td>
<td>kW</td>
<td>29.0</td>
<td>14.7</td>
</tr>
<tr>
<td>Pump Power Consumption</td>
<td>kW</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Water Consumption (max)</td>
<td>LPH</td>
<td>600.0</td>
<td>310.0</td>
</tr>
</tbody>
</table>

## Payback Period Calculation

| POWER COST | Rs/Unit | 7.5 | 7.5 |
| WORKING TIME | HOURS/YEAR | 3000.0 | 3000.0 |
| OPEX       | INR LACS   | 6.6  | 3.4  |
| CAPEX      | INR LACS   | 7.2  | 10.2 |
| COST DIFFERENCE | INR LACS | 2.9 | 2.9 |
| SAVINGS    | INR LACS   | 3.2  | 3.2  |
| DIFFERENTIAL PAYBACK PERIOD        | MONTHS | | 11.2 |

Sustainable Air Conditioning
INDIRECT EVAP COOLING – INDIAN HISTORY

- First recorded use in India was in mid 70’s and it used a cooling tower with coils.
- First use with integral Polymer Plate, Heat exchangers in India was done by Climate Control India Ltd. in 1993,
- Dhaliwal Tech Systems, Hyderabad was the first company to commercialize the concept and coin the term *Ambiator* for *Indirect Direct Evaporative Cooling* between 1995 - 1997
- Early adopters for the technology in India were ITC, Voltas, Wipro, TVS and some south based SMEs
- During 1997, I transferred the technology to Sumaya hmx ltd, Bangalore
- Now the state of the art technology is transferred to TORO COOLING SYSTEMS PVT. LTD. PUNE.
CONVENTIONAL AIR CONDITIONING
Cooling Generators

**Electric Chiller**
- HCFC
- Ammonia

**Absorption Chiller**
- Single effect
- Double effect
CONVENTIONAL AIR CONDITIONING

Sensible Gain = 8 kW
Latent Gain = 2 kW

20% FRESH AIR

EXHAUST AIR OUTLET

RETURN AIR FAN

80% RECIRC.

ROOM AIR

SUPPLY FAN

COOLING COIL

REHEATER BATTERY

DAMPER

ADP

M

W

S

ROOM

SUPPLY AIR

ROOM AIR

Sustainable Air Conditioning
CONVENTIONAL AIR HANDLING UNIT
CONVENTIONAL AIR CONDITIONING

Conventional Air Conditioners with their energy-hogging compressors and ODS chemicals as refrigerants still reigns supreme throughout the world.
“Differences in energy infrastructure, size and occupancy density of buildings, sustainability concerns, desirable indoor temperature and diurnal use of air conditioning will influence the energy use for cooling in developing countries.”

“Estimated potential increase in energy demand for Air conditioning for Mumbai city alone in very near future to be in the range of 24% of the total energy demand of whole of United States.”

Michael Sivak, U-M Transportation Research Institute, Ann Arbor, Michigan USA
With no serious regulatory frameworks in sight as yet, conventional air-conditioning use will certainly continue to increase globally.

Awareness of its environmental impact is beginning to change the ways in which some of the architects are approaching the challenge to cool buildings with alternative Low Energy Cooling technologies.

In fact, many planned and existing buildings can employ a variety of hybrid technologies to achieve comfortable indoor temperatures without resorting to the use of “off the shelf” conventional air conditioners.
FUTURE OF AIR CONDITIONING

IAC + CHILLED WATER

HYBRID AIR CONDITIONING
Toro Hybrid AHU Standard
Monsoon operation
Location - Mumbai

LEGEND
CFM DBT °C WBT °C
Gm/kg kJ/kg RH %

Patented process
100% FRESH AIR – HYBRID DEW POINT CONTROL

Tech integration

Exhaust of moist air

Sensible Heat Exchanger

Adiabatic Heat Exchanger

CHW Heat Exchanger

DB 40 C
WB 23 C

FAN

DB 30 C
WB 30 C

DB 21 C
WB 20 C

DB 18 C
WB 17.5 C
HYBRID AIR HANDLING UNIT

Sustainable Air Conditioning
Hybrid Air Handling unit being installed
Sustainable Air Conditioning
**DIFFERENTIAL COST PAY BACK**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>UNITS</th>
<th>CONVENTIONAL AHU</th>
<th>TORO HYBRID AHU</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR QUANTITY REQUIRED</td>
<td>CFM</td>
<td>16500</td>
<td>16500</td>
</tr>
<tr>
<td>SUPPLY AIR TEMP</td>
<td>°C</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>ROOM TEMP</td>
<td>°C</td>
<td>24 ± 2</td>
<td>24 ± 2</td>
</tr>
<tr>
<td>NO. OF SYSTEMS</td>
<td>NOS.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>SUMMER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL REFRIGEARTION NEEDED</td>
<td>TR</td>
<td>35</td>
<td>26</td>
</tr>
<tr>
<td>CHILLER UNIT POWER FOR SUMMER</td>
<td>kW</td>
<td>43.75</td>
<td>32.5</td>
</tr>
<tr>
<td><strong>MONSOON</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL REFRIGEARTION NEEDED</td>
<td>TR</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>CHILLER UNIT POWER FOR MONSOON</td>
<td>kW</td>
<td>43.75</td>
<td>37.5</td>
</tr>
<tr>
<td><strong>WINTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL REFRIGEARTION NEEDED</td>
<td>TR</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>CHILLER UNIT POWER FOR WINTER</td>
<td>kW</td>
<td>23.75</td>
<td>0</td>
</tr>
<tr>
<td>FAN INPUT POWER</td>
<td>kW</td>
<td>11.0</td>
<td>11.0</td>
</tr>
<tr>
<td>PUMP INPUT POWER</td>
<td>kW</td>
<td>0</td>
<td>0.25</td>
</tr>
<tr>
<td>TOTAL POWER FOR SUMMER</td>
<td>kW</td>
<td>54.8</td>
<td>37.3</td>
</tr>
<tr>
<td>TOTAL POWER FOR MONSOON</td>
<td>kW</td>
<td>54.8</td>
<td>48.8</td>
</tr>
<tr>
<td>TOTAL POWER FOR WINTER</td>
<td>kW</td>
<td>34.8</td>
<td>11.3</td>
</tr>
<tr>
<td>POWER COST</td>
<td>RS/KWH</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>WORKING TIME</td>
<td>HOURS/YEAR</td>
<td>6000</td>
<td>6000</td>
</tr>
<tr>
<td>OPEX</td>
<td>INR LACS</td>
<td>21.6</td>
<td>14.6</td>
</tr>
<tr>
<td>CAPEX</td>
<td>INR LACS</td>
<td>8.0</td>
<td>21.0</td>
</tr>
<tr>
<td>COST DIFFERENCE</td>
<td>INR LACS</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td>SAVINGS</td>
<td>INR LACS</td>
<td></td>
<td>7.1</td>
</tr>
<tr>
<td><strong>DIFFERENTIAL PAYBACK PERIOD</strong></td>
<td>MONTHS</td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>
NEW CONCEPTS & DESIGNS

- Twin Heat exchangers in Tandem
- 50% saving in compressor size/chilled water use
- Generated cooling used “as and when and as much as required”
- Direct Drive- No belts-Backward curve plug flow fans
- Blow Through Design-formed & smooth air flow
- PID Controller Driven VFD –modulates air quantity as required
- Built in control panel - Process control by Dedicated PLC
- All wet components moulded FRP-no corrosion-Long life
- Universal air outlet
- Any level of filtration
Play Video
WHAT MAKES HYBRID IDAC ATTRACTIVE

- Annual operating cost reduced by 30 to 50% or more
- Using sensible cooling if chiller fails
- Minimum refrigeration used – environment friendly
- Fresh air cooling at lowest energy cost – Best IAQ
- VFD controlled fans for further energy savings
Till the day we can use alternative forms of energy in a wide scale, turning on the air conditioner will always mean that the earth will be affected.

The only way to limit the damage is by using highly energy efficient air conditioners which require less power to run.

Increasing awareness of environmental issues has led to development of a large number of energy conservation technologies for buildings, especially in more developed countries.

Indirect Direct Evaporative air conditioning lowers the carbon foot print by 50 - 70%

*Based on 10 million window and split ACs as working stock annual carbon emissions exceed 30000 Tones / year.

Nearly 50% more can be added for industrial and commercial applications.

New Hybrid air conditioners can reduce the emissions by 50% or more.

*Council on Energy, Environment and Water-working paper 2014/7
SOME SPECIAL APPLICATIONS

- Hospitals
- Multiplexes
- Large homes
- Educational Institutions
- Railway Buildings
- Public Buildings/Conference Halls
- Data Centers
- Electrical & Process control rooms
- Air Craft Hangers
- 20-30% fresh air applications
- 100% fresh air – Dew point control
- Under floor air conditioning
- Energy Efficient replacement for conventional AC
Darshi Dhaliwal
Principal Technologist
Technology Transfer & LEC Audit Unit

AIR INNOVATIONS
RH-47, LAKE PARADISE
Opp. CRPF Campus, N.H. 4
Talegaon Dabhade-410506
Maharashtra
INDIA

www.airinno.com
Email dd@airinno.com