



Energy Efficiency in

Compressed Air & Chilled Water Systems

Presentation by:

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ITC Limited - Paperboards & Specialty Papers Division (Unit – Bhadrachalam)



**India`s largest & Most technologically advanced Integrated Pulp & Paperboard Manufacturing Facility
Pioneer in Ozone bleaching, BCTMP Technology in India**



Certifications & Compliances



Category	Certification/ Compliance	Description
Manufacturing & Safety	ISO 9001	Quality Management System (QMS)
	ISO 14001	Environmental Management
	OHSAS 18001	Occupational Health and Safety Management
	ISO 50001	Energy Management
	BRC Global Standard	Hygiene & quality for Packaging & Packaging Materials
Regulatory	SMETA 4 Pillar	Member of SEDEX (Supplier Ethical Data Exchange)
	REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) - a European Union regulation
	RoHS	Restriction of Use of Hazardous Substances like lead, cadmium, mercury
Food Contact	BfR Recommendation XXXVI	German Regulations for migration
	US FDA CFR 21, 176.170	For contact with aqueous and fatty food
	US FDA CFR 21, 176.180	For contact with dry food



Core Competencies

Unit - Bhadrachalam

- ❖ 8.0 Lakh TPA Paper and Paper Board Production Capacity
- ❖ 1.2 Lakh TPA Bleached Chemi Thermo Mechanical Pulp (BCTMP) Pulp Capacity
- ❖ 100% Self Sufficiency in Power through in-house Co-Generation Power Plant
- ❖ **Green Covered area so far 9.53 Lakh acres** through Social and Farm Forestry.
- ❖ **47.4% of total energy in 2022-23 is from RENEWABLE SOURCES**
- ❖ **Carbon Negative for 18 Consecutive years**
- ❖ **Water Positive for 21 years in a row**
- ❖ **Solid Waste Recycling Positive for the last 16 years**
- ❖ **Green Co Platinum Plus Certified by CII-GBC**
- ❖ TPM Methodology for manufacturing excellence
- ❖ Adopting I 4.0, IOT Based predictive models for energy & process optimization

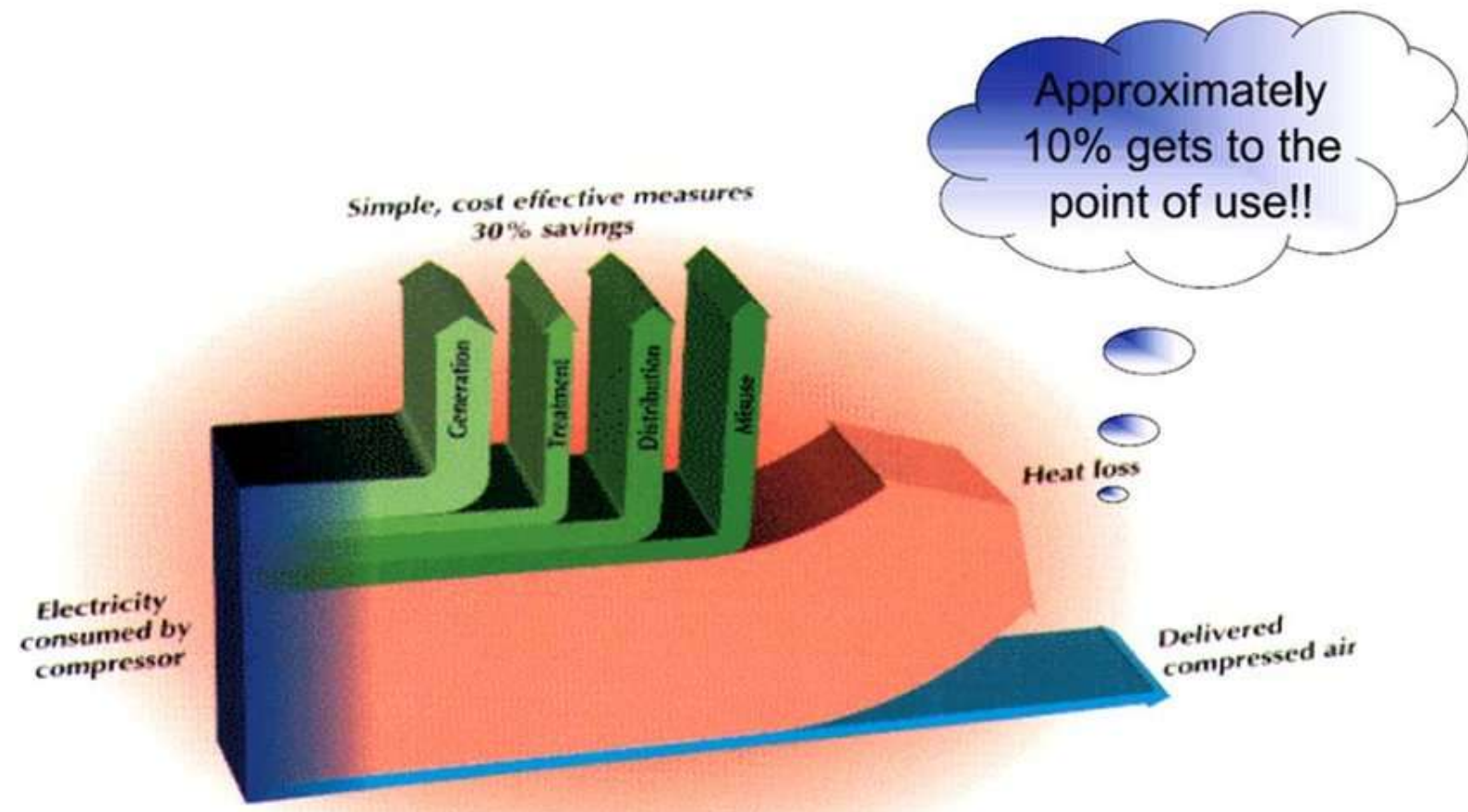




Energy Efficiency in Compressed Air System



Sankey Diagram for Compressed Air



Where to avoid Compressed Air – Portable tools



Compressed air operated portable tools



Electrical or battery operated portable tools

Pneumatic equivalent 70 kw can be operated with **electrical 7 kw**



Where to avoid Compressed Air – Self Cleaning



Apart from energy consumption, such injuries may happen while cleaning with common industrial compressed air jet



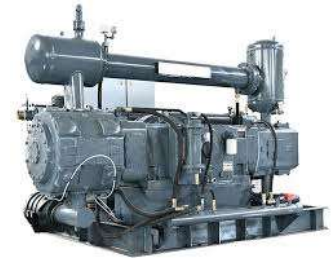
For such applications, special equipment with air blower or transvector nozzle will save energy in compressed air system to large extend.



Initial Arrangement at ITC PSPD in 2000

4 locations, 18 Compressors

Location	Cmprs	Type	Kw	Air flow	Pressure
Utility compressor house	1	Reciprocating	160	14.8	6.5
Utility compressor house	2	Reciprocating	160	14.8	6.5
Utility compressor house	3	Reciprocating	160	14.8	6.5
Utility compressor house	4	Reciprocating	160	14.8	6.5
Utility compressor house	5	Reciprocating	160	14.8	6.5
Utility compressor house	1	Reciprocating	110	14.8	4
Utility compressor house	2	Reciprocating	110	14.8	4
Utility compressor house	3	Reciprocating	110	14.8	4
Utility compressor house	4	Reciprocating	110	14.8	4
Utility compressor house	5	Reciprocating	110	14.8	4
Coal fired boiler 4	1	Reciprocating	90	15.1	3
Coal fired boiler 4	2	Reciprocating	90	15.1	3
Coal fired boiler 5	1	Reciprocating	90	15.1	3
Coal fired boiler 5	2	Reciprocating	90	15.1	3
Paper Machine 4&5 compressor house	1	Reciprocating	250	35	6.5
Paper Machine 4&5 compressor house	2	Reciprocating	250	35	6.5
Paper Machine 4&5 compressor house	3	Reciprocating	250	35	6.5
Paper Machine 4&5 compressor house	4	Reciprocating	250	35	6.5



Total air requirement : 14928 NM3/hr, Total Power : 1940 KW, Sp.Power Cons : 0.13 kw/NM3

Energy Efficiency option for such arrangement



- **Centralize**

By centralizing all the reciprocating compressors to Utilities or any other section and supply mill wide, the compressors running hours can be drastically reduced.

- **Optimize**

There are automation solutions which will on/off as well as load/unload based on pressure set point using PLC etc. These automation solutions will further reduce specific power consumption in compressed air.

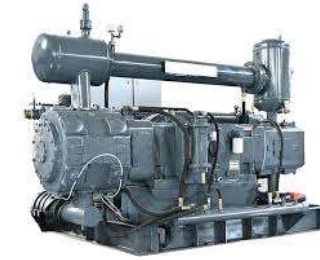


Replace Reciprocating type with Centrifugal Compressors

ITC PSPD BCM in 2010

5 locations, 13 Compressors

Location		Compressors	Make	Kw	Air flow	Pressure
Utility compressor house	3 Stage Centrifugal	Centac 1	Ingersoll Rand	710	95	6.5
Utility compressor house	3 Stage Centrifugal	Centac 2	Ingersoll Rand	950	120	6.5
Utility compressor house	3 Stage Centrifugal	Centac 3	Ingersoll Rand	1440	200	6.5
Coal fired boiler 4	1	Reciprocating	KG Khosla	90	15.1	3
Coal fired boiler 4	2	Reciprocating	KG Khosla	90	15.1	3
Coal fired boiler 5	1	Reciprocating	KG Khosla	90	15.1	3
Coal fired boiler 5	2	Reciprocating	KG Khosla	90	15.1	3
Coal fired boiler 7	1	Reciprocating	KG Khosla	90	15.1	3
Coal fired boiler 7	2	Reciprocating	KG Khosla	90	15.1	3
Paper Machine 4&5 compressor house	1	Reciprocating	KG Khosla	250	35	6.5
Paper Machine 4&5 compressor house	2	Reciprocating	KG Khosla	250	35	6.5
Paper Machine 4&5 compressor house	3	Reciprocating	KG Khosla	250	35	6.5
Paper Machine 4&5 compressor house	4	Reciprocating	KG Khosla	250	35	6.5



Reciprocating compressor



Centrifugal compressor

Total air requirement : 34348 NM3/hr, Total Power : 4120 KW, Sp.Power Cons : 0.12 kw/NM3



Zero air loss traps



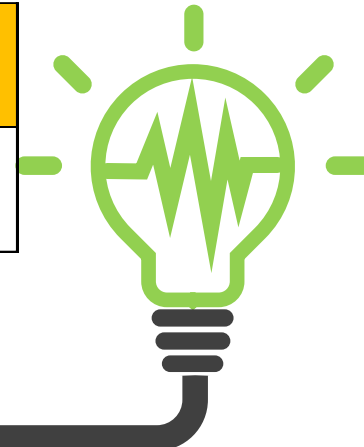
Timer based traps for receivers



Zero air loss traps

**Savings : 13 kw
Eq Annual CO₂
reduction : 172 Tons**

Year	Investment Description	Investment in Crs
2017-18	23 no's zero air loss traps	0.15



Investment : Rs 15 lacs, Saving : Rs 5.9 Lacs per annum, Pay back : 2.53 years



IFC (Intelligent Flow Controller) Units



- If you have different set points of user end and you have centralized compressed air system, then this is ideal system for saving energy.
- The IFC has to be located in user end with set point maintained as per user requirement. This unit will precisely maintain the pr. Set point as per user, thereby avoiding higher pressure of input compressor to user.

**Savings : 118 kw
Eq Annual CO₂
reduction : 1562 Tons**

Year	Investment Description	Investment in Crs
2022-23	17 IFC units installation at user ends	1.38

Investment : Rs 138 lacs, Saving : Rs 52 Lacs per annum, Pay back : 2.22 years



Periodic Leakage Detection



	No of leaks	Air loss in CFM	Eq Energy loss in kw
2020	1345	2133.8	305.142
2022	567	1145.4	167.767



**Savings : 305 kw
Eq Annual CO₂
reduction : 2766 Tons**

Flange and Ferrule joints



Centrifugal blower in place of lobe blower in ETP



Dissolved oxygen levels in MBBR improved from 0.3 to 1.4 ppm.

Savings : 109 kw
Eq Annual CO₂ reduction : 1443 Tons

Description	UOM	Blower1	Blower2	Sulzer Blower
Actual air flow	Nm3/hr	4200.0	4550.0	8000.0
Actual power consumed	kW	191.7	156.1	186.6
Specific Power Consumption	kW/hr/Nm3	0.0456	0.0343	0.0233



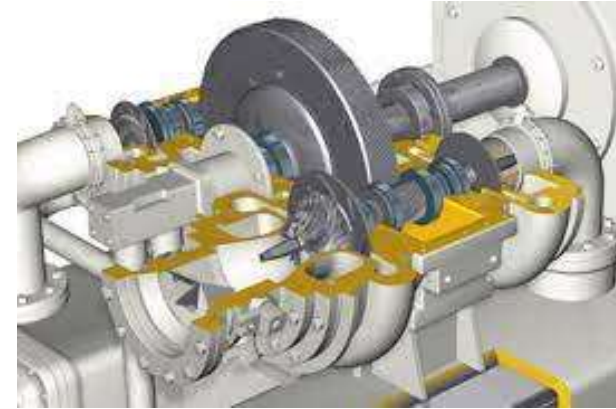
Investment : Rs 65 lacs, Saving : Rs 48 Lacs per annum, Pay back : 1.35 years



Optimum compression & avoid bleeding into lower pr.



3 stage 6 bar compressor running at 4 bar
710 kw, 5700 NM3/Hr +
2 no's Recip compressor
200kw, 954 NM3/Hr
+ 35 M3 per hour bleed from 6 bar air



2 stage 4 bar compressor
900 kw, 10800 NM3/Hr

Savings : 307 kw
Eq Annual CO₂
reduction : 2784 Tons

Investment : Rs 187 lacs, Saving : Rs 148 Lacs per annum, Pay back : 1.26 years



Dew Point Consideration & Dryers Selection



Refrigerated Dryer
Dp : $< 0.2 \text{ kg/cm}^2$
Dew point min : $2 \text{ }^\circ\text{C}$



Heat of Compression Dryer



Heat reactivated Dryer

Desiccant Dryers
Dp : 0.6 kg/cm^2
Dew point min : $-60 \text{ }^\circ\text{C}$



Summary of savings

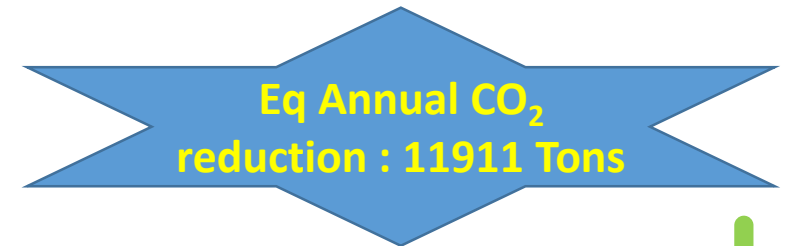


Year	Compressors Details	Locations	Power Kw	Air NM3/Hr	Sp. Gen NM3/kw	Sp. Power kw/NM3
2000	18 reciprocating compressors	4 areas in mill	1940	14928	7.695	0.130
2010	3 centrifugal & 6 reciprocating	5 areas in mill	4120	34348.8	8.337	0.120
2020	4 centrifugal & 1 reciprocating	2 areas in mill	4550	38730	8.512	0.117
2024	4 centrifugal compressors	1 area in mill	4540	42000	9.251	0.108

Centac1 (2003, 0.65 Crores), Centac2 (2006, 0.9 Crores)

Centac3 (2007, 1.17 Crores), Centac4 (2019, 1.3 Crores)

Centac5 (2021, 1.6 Crores), New Centac1 (2023, 1.87 Crores)



By implementing all the above energy saving investments and practices, the specific power brought down from **0.130 kw/NM³** to **0.108 kw/NM³** (equivalent to saving of about **0.9 MW** for ITC PSPD BCM unit compressed air consumption of 42000 M³/Hr)





Energy Efficiency in Chilled Water System



Chillers



- Try to Centralize chilled water system, the chillers become larger and specific energy will come down. Also with larger chilled water and cooling tower pumps, the pumping energy will also come down.
- Switch over from Vapor Absorption Chiller to Vapor compression chiller, if the thermal energy is not from waste.
 - The COP of VAM chiller is around 1.3 to 1.5
 - The COP of VC chiller is around 4



Chiller replacement case studies at ITC PSPD BCM



Year	Chillers	Locations	Electrical Power consumed	Steam saved	Net Annual Savings
			Kw	TPH	Lacs Rs
2018	VAM chiller replaced with 325 TR Screw Chiller	PM6	202	1	8.24
2019	VAM chiller replaced with 340 TR Screw Chiller	PM4	206	1	15.51
2019	2 nos VAM chillers replaced with 1 nos 600 TR Centrifugal Chiller	Pulp mill ClO2 plant	390	3	51
2021	2 nos VAM chiller replaced with 2 nos 600 TR Centrifugal Chillers (1200 TR)	Pulp mill Ozone plant	780	5	160

The investments in electrically operated chillers are as follows:

Screw Chillers (2018, 42 lacs investment & 2022, 38 lacs investment)

Centrifugal Chillers (2019 & 21, 450 lacs investment)

Total investment in electrically operated chillers is 5.3 crores, **the payback is about 2.25 years.**

Eq Annual CO₂ reduction : 10496 Tons



Eco friendly low/medium pressure refrigerant



	UOM	Vendor1	Vendor2	Vendor3	Vendor4	Vendor5
Refrigerant	-	R 134a	R 514a	R 134a	R 134a	R 134a
Motor Rating	KW	436	390	415	441	421
Landed price	Lakhs Rs	114.5	119.1	131.7	132.1	142.7

Description	R514a	R134a
Global Warming Potential	< 2	1320
Ozone Depletion Potential	0	0
Energy Efficiency	13.5% over next competitor	Baseline
Leakage Rate	< 0.5% per year	2 % per year
Short Atmospheric Lifetime	22 days	13.4 years

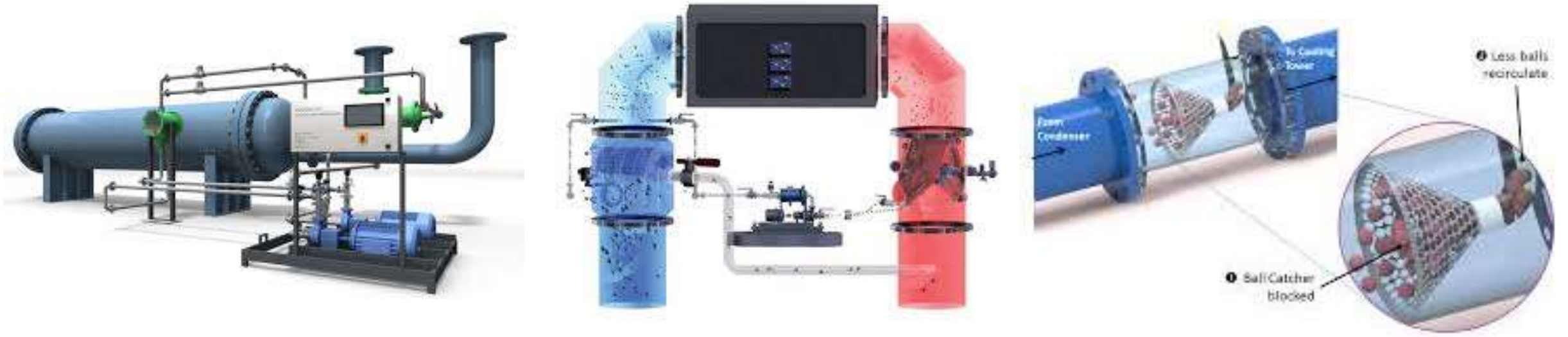


Pulp mill ClO2 plant and Ozone plant chillers are replaced with the same.

Investment 450 lacs, savings per annum 211 lacs, **payback period 2.13 years.**



Auto Tube Cleaning System



20% energy reduction from unclean condenser to a clean condenser.

Total investment in 8 nos ATCS for 8 nos running chillers is 0.5 crores, **the payback is about 2.39 years.**



Air Conditioner to Chilled Water Fan Coil Units



Window AC



Split AC



Wall mounted
Chilled Fan Coil Unit



Floor mounted
Chilled Fan Coil Unit

If there is margin in chiller replace Air Conditioners with AHUs or FCUs.

Centrifugal Chiller: 600 TR, Power: 390 kw, **Specific power: 0.650 kw/TR**

Screw Chiller: 340 TR, Power: 206 kw, **Specific power: 0.605 kw/TR**

Air Conditioner: 1.5 TR, Power: 1.6 kw, **Specific power: 1.05 kw/TR**

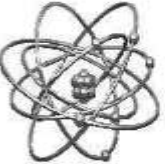
Air conditioner shifting to Chilled water not only saves power, but also saves in GHG emissions by reduction in refrigerant top up in operational years.


With auxiliary power added also, there would be minimum **saving of 25% energy.**




Nano particles in Chilled water Circuit

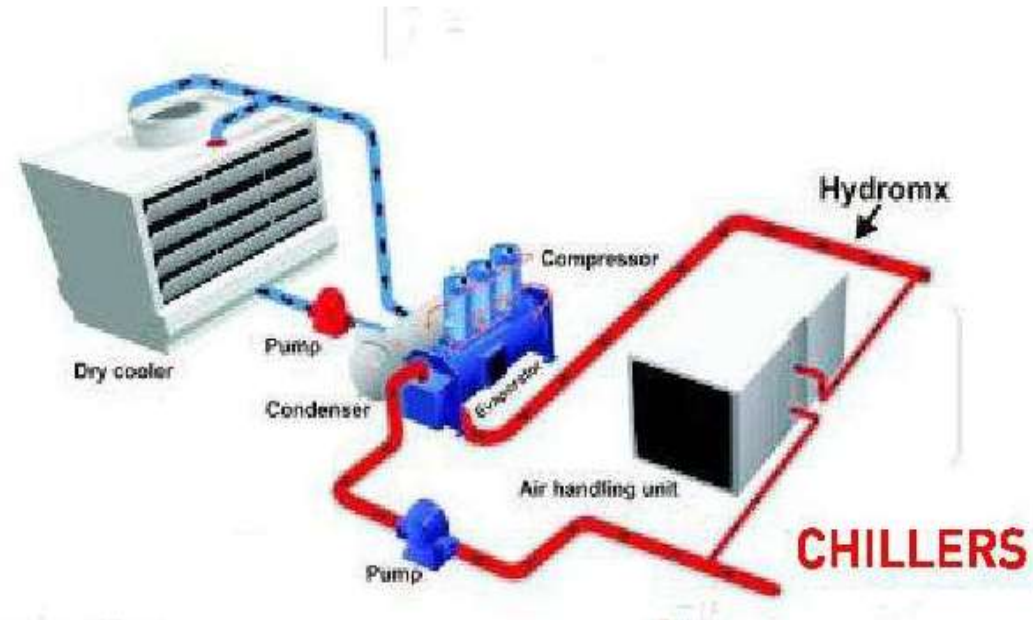


 Atomic Structure of Metal is closely knitted
Good Conductor of Heat

 Atomic Structure of water is Less Viscous
Not as good as metal in Heat Conduction



HYDROMX is the best of both (Metal & Water), as the HYDROMX particles help water gain metallic properties and results in more efficient heat transfer.



Nano particles to be added in closed chilled water circuit in 1:1 ratio of water.

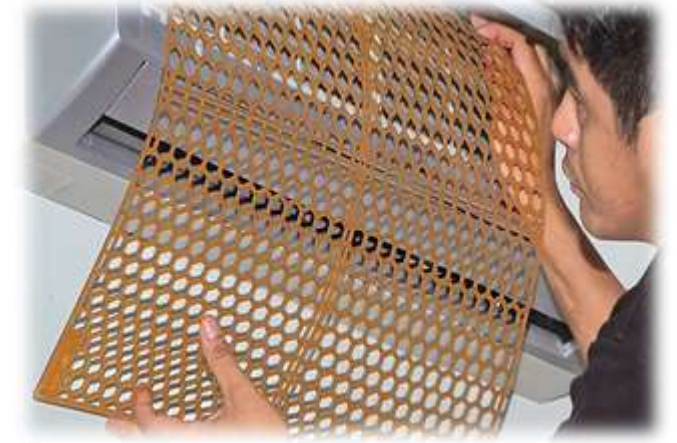
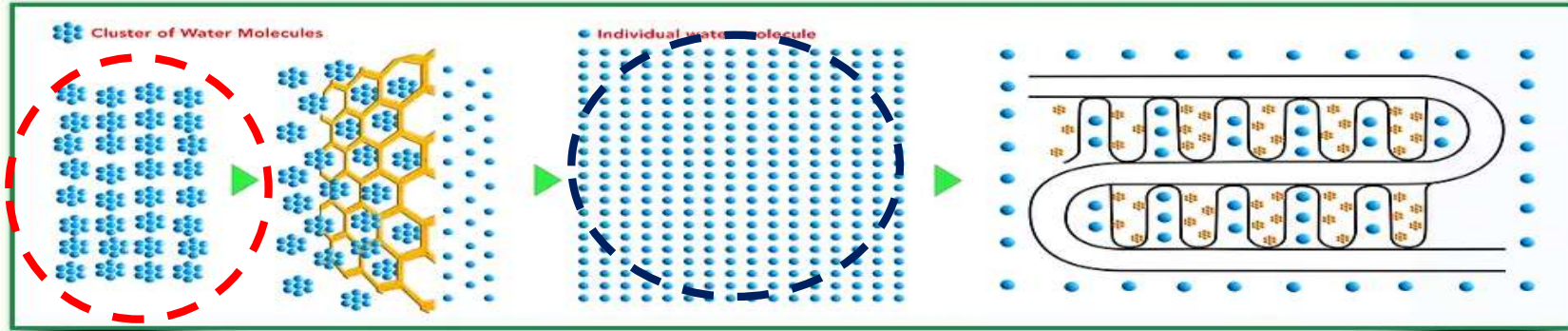
In closed loop chilled water circuit, if nano particles are added, it will improve heat transfer and reduce the load on chiller compressors thereby resulting in energy saving of about 25%.



Hexagonal mats in Air circuit of HVAC



It is a fully sustainable innovative product developed, produced and patented in Japan. It is made of a special ceramic that naturally emits specific infrared rays able to break down clusters of water molecules present in the air so that a larger surface area is in contact with the fins of the AC unit. This allows the AC unit to reach the desired temperature faster and reduces the load on the compressor so that it is able to work more efficiently consuming less energy.



Other Benefits :

- Air Purification improvement due to *ionization*
- PM2.5 and PM10 reduction by up to ~ 60%
- Pathogens removal – Effects on Viruses
- No risk exposing oneself to high quantities of negative air ions
- “Air quality” enhancement more efficiency & energy at work



The mats provided in ACs/HVAC system will reduce power consumption by 25%.





Thank You