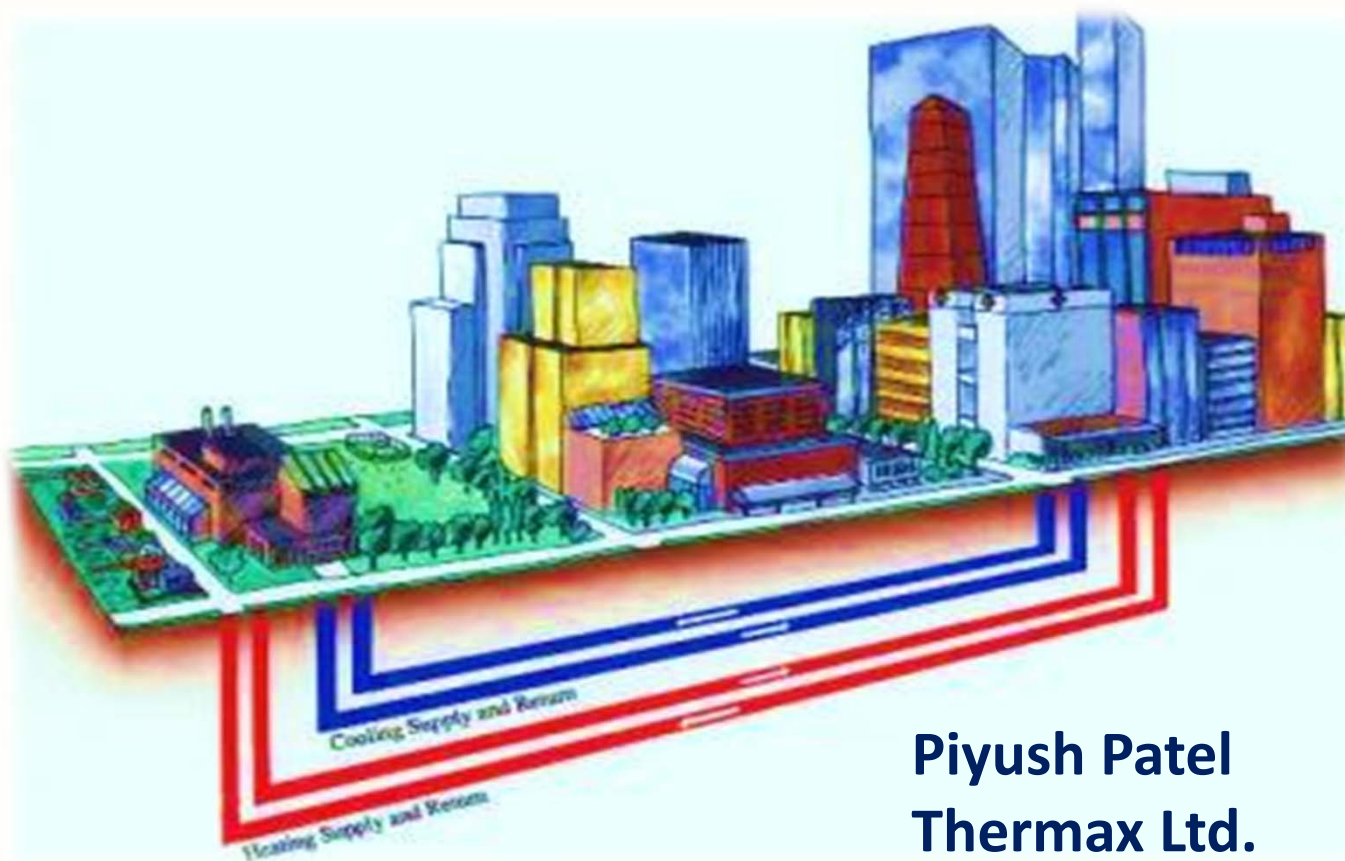


Case Studies – Multi-Energy Absorption Chillers on CHP & Renewables for Campus Cooling



Piyush Patel
Thermax Ltd.

Topics Covered

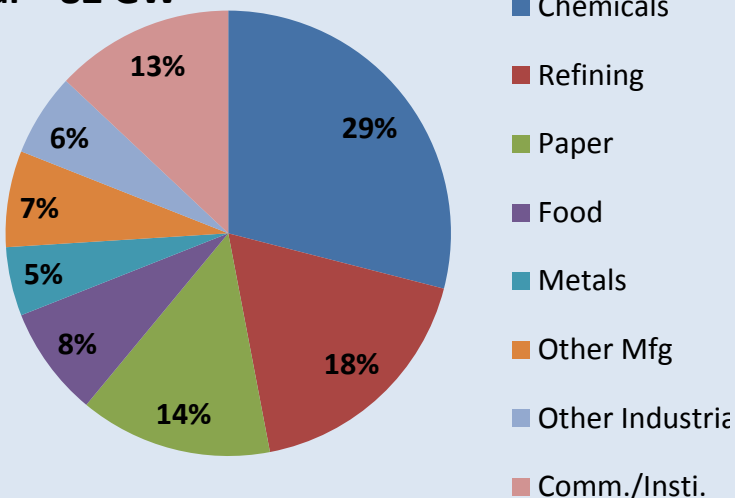
- CHP and Campuses
- Ways to get Cooling from CHP
- Advantages of multi-energy absorption chillers & options available
- Sectors-wise case studies
- Recent developments – triple effect chillers and heat pumps; their installation experience and chiller on renewables

CHP in Campuses

Present CHP Installed base in USA:

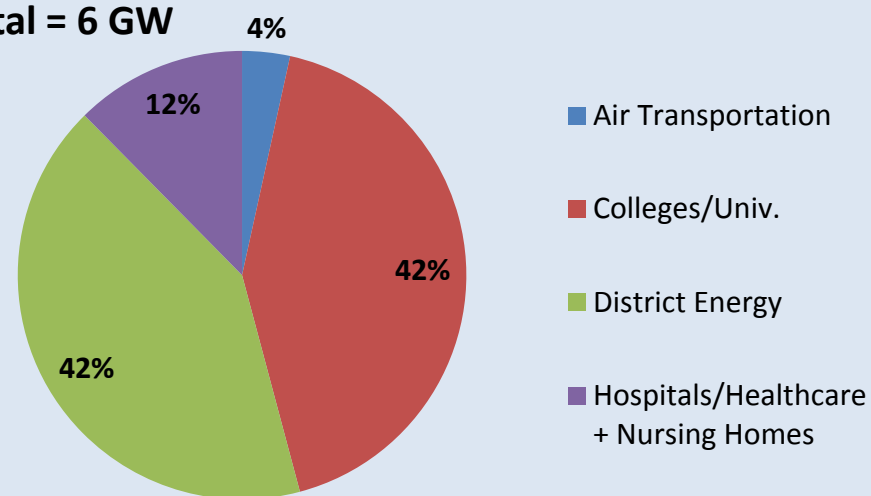
Out of 82 GW of installed CHP capacity in USA, some 6 GW is in Colleges & Universities, Hospitals & Nursing Homes, Airports and District Energy. This can be further grouped as below.

Total = 82 GW



Sector-wise Installed CHP - USA

Total = 6 GW



Installed Capacity in US Campuses

Campuses are ideal candidates for CHP



Colleges & Universities:

- Increased load in Campuses
- Replacement of aging boilers
- High occupancy levels
- Uniform thermal loads
- Green building initiatives



Hospitals :

- 24/7/365 energy demands
- High electrical and thermal loads
- Quality of Power for clinical equipment
- Reliability and resiliency

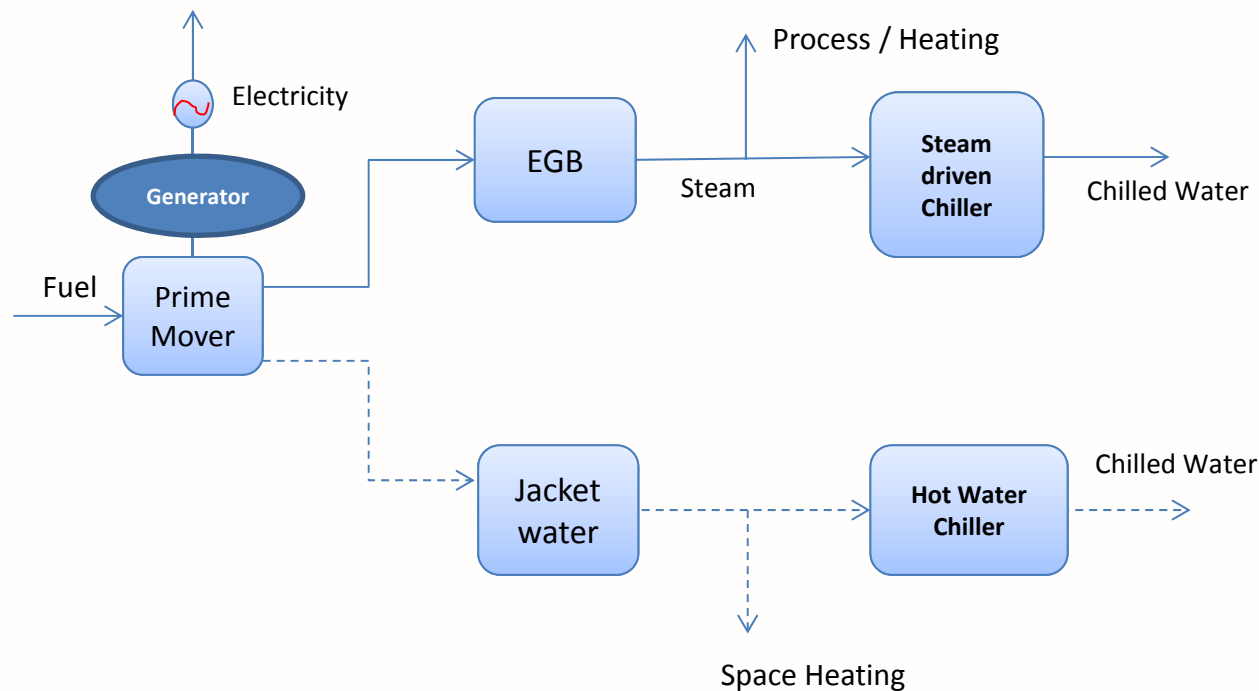


Airports:

- High electrical and thermal loads
- Long operating hours
- Reliability and resiliency

Cooling CHP

Conventional CHPC system – Cooling perspective

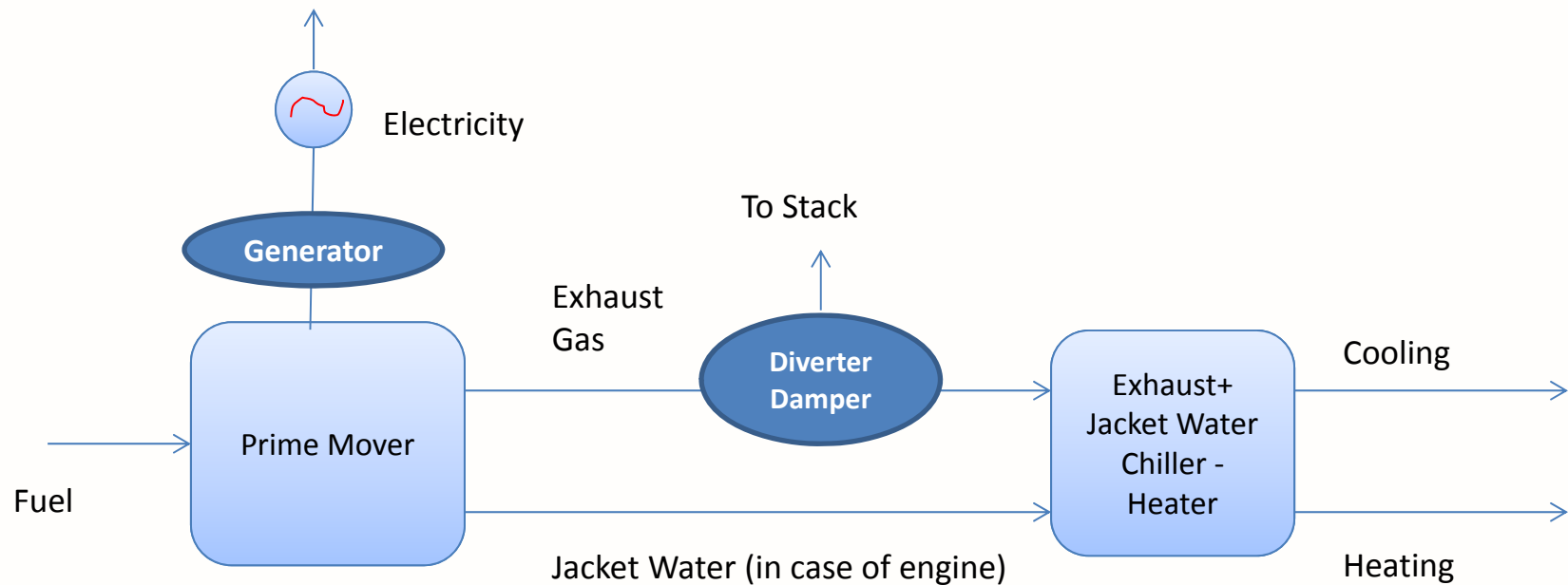


In the conventional system, exhaust gas heat is recovered in terms of steam (or hot water) and this is then used to drive chiller to meet cooling requirements using:

- Steam turbine driven centrifugal chillers
- Steam driven absorption chillers

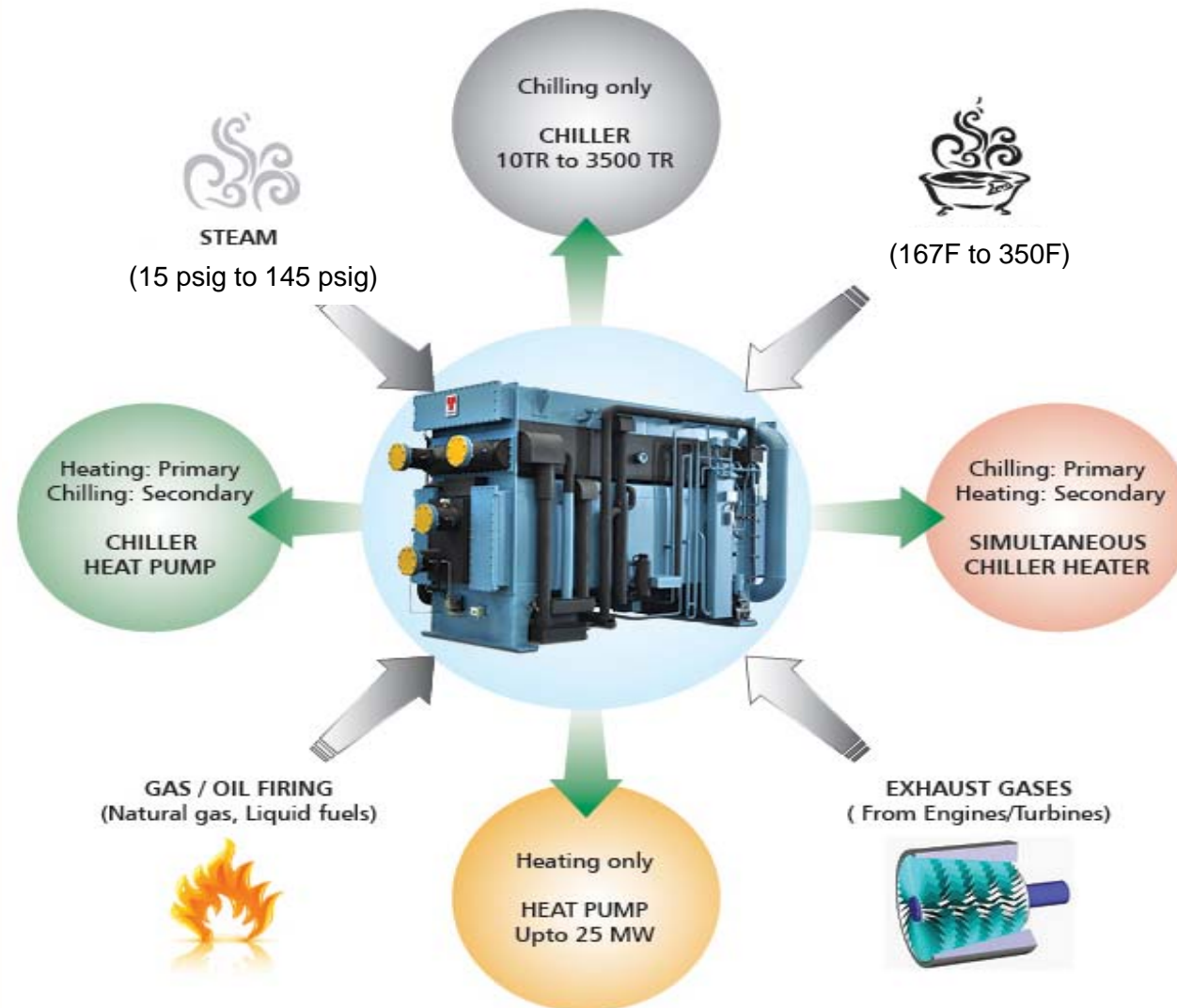
Cooling CHP

Cotemporary CHPC system – Cooling perspective



In the temporary system, a single “multi-energy” absorption chiller can be driven by exhaust gas and jacket water of engine to meet cooling and heating load

Absorption technology- Multi-energy to Multi-Utility



Tri-generation – Meeting Power and Thermal demands

California State University, Fullerton - USA



CSUF is a major Univ. with 236-acre campus, 29 buildings set in Fullerton, about 40km from downtown Los Angeles

Has more than 37,000 students and approximately 1,800 full- and part-time faculty members. The University offers 107 degree programs in eight colleges.

- Exhaust from 4.4 MW Natural Gas Turbine – Mercury 50
- 2 nos. x 1300 TR Multi energy absorption chiller-heater
- Heat Source : Exhaust Gas + Supplementary Firing. Exhaust gas from turbine is split and fed to two chillers
- Capable of producing Chilled & Hot Water Simultaneously
- Both chillers in parallel providing flexibility in operation: Two units as chillers in summer, One chiller + One heater in shoulder months and two heaters in winter months.

Highlight: High Temp difference in Chilled water loop = 23°F (64/41°F), which helped changed the scheme from two chillers in series to parallel giving great flexibility in operation

California State University, Fullerton - USA

- The plant saves the university \$1.6 million in utility costs.
- CSU size went up from 3.87 million gross sq.ft to 5.87 million sq.ft.
- Electrical costs came down from \$4.5 million (when are was 4.74 million gross sq.ft) to \$2.5 million in 2012/13.



University of Central Florida, Orlando Campus - USA



University of Central Florida, Orlando Campus:

The University of Central Florida is located in Orlando, Florida with campus of spanning 1415 acres. The university offers over 200 degree options through twelve colleges and twelve satellite campuses throughout Florida. Campus has unique layout with a series of concentric circles

Installation has:

- Exhaust from 5.5 MW Mitsubishi Natural **Gas Engine**
- 1000 TR Multi energy absorption chiller
- Heat Source : Exhaust Gas + Jacket Water



Marina Thermal Power Plant, NJ , USA



Owner: Marina Energy
Developer: DCO Energy,

This facility supports Borgata Casino complex and surrounding area of Atlantic City in New Jersey.

It has 8 MW emergency power, 25,000 Tons chilled water and 350,000 MMBtu heating.

Borgata Casino, one of the largest consumers of the utilities has 2108 rooms and about 15000 m2 gaming place.

Marina Thermal Power Plant, USA (Tri-generation Plant) :

- 2 nos. x 1000 TR Low temp Hot Water absorption chillers
- Heat Source: 200°F Hot water generated by the 8MW Taurus 70 gas turbine heat

Highlights: **Low Temp hot water driven chillers with chilled water outlet temp of 39F**, low CHW temp is important parameter to take care of heat gain while distribution over larger area.

Data Centers

University of Toledo, OH, - USA



Univ. of Toledo has 450 acres of Health Science campus and 160 acre satellite campus in Scott Park neighborhood of Toledo.

Has about 20,000 students & over 100 major buildings with combined area of about 60M sq.ft.

- Combined exhaust gas from (4) Capstone C65 micro-turbines, generating total 260kW power
- Thermax chiller – heater: 100 TR Cooling, 266 kW heating
- Capable of producing Chilled & Hot Water Simultaneously.
- Chilled water is used to cool the data center, while hot water is used to heat swimming pool.

Similar Installations:

- **IBM Data Center, Syracuse Univ., NY** – (2) 150 TR exhaust gas driven two stage chillers on (12) Capstone C 65 turbines cooling data center and nearby university building
- **PSECU, PA** – 300 TR exhaust gas + back up gas fired chiller on Capstone C1000, 1MW MT
- **Citibank Datacenter, UK-** (2) 300 TR hot water driven chillers on GE Jenbacher engines

Airports

Rome Airport, Italy



Rome Airport has a total surface area of 1600 hectares with 2.5 million sq.ft of terminals & has electrical demand of 21 ~ 26 MW.

- Single stage hot water driven chillers – 2 nos. 1300 TR + 2 nos. 1000 TR
- Power generation by 3 rolls Royce engines, each producing 8.5 MW.
- 90% of electrical and thermal load requirement is met by the CHP plant

Similar Installations:

- **Berlin Airport-** 2 nos. 370 TR exhaust gas driven two stage chillers on 2 MW CAT engines
- **Perth Airport-** 2nos. 500 TR exhaust gas + jacket water driven multi-energy chillers on GE Jenbacher 2MW engines
- **Istanbul Airport-** 2 nos. 400 TR exhaust gas + jacket water driven multi-energy chillers on 2MW MWM engines

Micro-grids

Fort Knox, KY



Part of smart micro-grid network.

With 2MW Caterpillar gas engine, each building has a different solution based on the needs – ideal case of cooling options available.

- 640 TR Single stage hot water driven chiller for hospital
- 495 TR Two stage exhaust gas driven chiller for data center cooling
- 705 TR Exhaust gas + jacket water driven chiller for Human Resources building
- 430 TR Two stage steam driven chiller (from exhaust gas boiler) was also planned, but postponed later.

This 109,000 acres Army post has witnessed thunderstorms, tornadoes and the worst of them – the ice storm of 2009 leaving many buildings without power for as high as 10 days.

The 8MW CHP is part of 44MW project and the engines will run 24/7.

Sacramento Municipal Utility District

SMUD



Meeting electrical and thermal demands

- Heat from the engines is converted into hot water at 205F.
- 120 TR single stage hot water driven chiller producing 42F chilled water for building air-conditioning
- 692 MW-h electricity saving per year – equal to powering 58 households
- CO2 savings is 488 Tons/year equivalent to emission by 100 cars per year

SMUD is sixth largest electricity company in USA that is publicly owned and serving over 1.4 million customers in 900 square miles. There are **three Tecogen Inverde CHP modules of 100kW each** to supply power to SMDU's central utility plant and field reporting facility to serve sensitive loads that need to remain operational during utility electrical outages. Total of 300 kW power meets the power needs of SMUD headquarter.

Highlights: High Temp difference in Hot water loop = 40F (205 in/175 out), low HW flow saves pumping cost. Chiller with enclosure for outdoor installation.

Thermax's Experience on different Prime movers

Engines

HW- Colussa Casino, CA; Ft. Knox, KY; Brevoort East, NY

Exhaust Gas only- Fort Knox, KY; Berlin Airport, Germany

Exhaust Gas + Jacket water- UCF, Orlando, FL; Perth Airport, Australia



Turbines/Micro-Turbines

Exhaust gas only- CSU, Fullerton, CA; IBM Data center, Syracuse Univ, NY

Exhaust gas heat recovery in various forms—

- LT HW (~200F)- DCO Marina Thermal Plant, NJ; Paramount Studios, CA
- HT HW (~350F)- 29 Palms, CA
- Steam (15~150 psig)— State of Michigan, MI; 29 Palms, CA; Ferrero Rocher, ON,CA

Renewables – Solar/Biomass

Crow Canyon Medical Center, Danville, CA



- High temp hot water (350F) from 75 Chromasun MCT collectors with 3352 ft²
- Thermax two stage chiller : 50 TR Cooling irrespective of solar heat
- Chiller is fitted with natural gas burner that comes into play to boost the capacity in cloudy weather

Highlights:

First US medical facility to provide solar air cooling/heating & domestic water heating

Estimated annual offsets:

- Electricity: 145,000 kWh
- Gas: 1100 therms
- Carbon: 26 cars off the road



Solar Cooling at Model Football Stadium, Qatar



500 seat model stadium cooled using Thermax double effect absorption chiller using hot water generated by Fresnel collectors from German manufacturer Mirroxx. Qatar will be hosting the 2022 FIFA World Cup, a tournament that will involve 32 national teams. Qatar will be the first Arab nation to host this event.

Recent Developments in absorption technology

- Low chilled water outlet temp: **32F (0°C)**
- Subfreezing chilling requirements: Hybrid chillers (driven partly by heat source and partly electricity) **up to -40F (-40°C)**
- Heat Pumps: Thermax can manufacture a single heat pump **up to 40 MW**
- Heat Pump type II (Heat transformers): **Steam up to 72 psig (5 barg)** using low grade heat source (temp. range 250F/120°C)
- High efficiency chiller – heaters : **30% more** efficient than conventional
- Triple effect chillers – **the only manufacturer** to commercially launch triple effect chillers
 - Chillers supplied on steam (225 psig onwards)
 - Chillers supplied on hot water (400F onwards)
 - Chiller tested successfully on exhaust gas from gas engine
 - Chiller on natural gas under development

Renewables – Solar/Biomass

Biomass driven district cooling at Thermax factory, India



About the Installation:

- Location : Thermax factory at Pune, India
- Two main buildings cooled using 300TR x 2 chillers Total Capacity = 600 TR
- A 2 ton biomass fired boiler generates steam at 377psi g pressure.
- The chillers have been running since 2013.

Highlights: **Highest efficiency** (COP=1.8) triple effect steam driven chillers **in the world** running on biomass.

Similarly, a triple effect 30TR chiller on hot water collectors using parabolic troughs is operating at MNRE Delhi, India since 2011.

Triple Effect Chiller in Tri-generation System

Double Effect



2 MW Gas Engine

→ Exhaust gas



COP = 1.43



Cooling possible
= 450 TR

Triple Effect



2 MW Gas Engine

→ Exhaust gas



COP = 1.8



Cooling possible
= 575 TR

Note: Chiller designed on engine exhaust only.

Engine specification:

Exhaust gas flow rate = 27,320 lb/hr; Exhaust gas Temperature In/Out = 850 / 300°F

Advantages over steam turbine driven chillers

	Steam Driven Centrifugal chiller	Double effect Vapor Absorption chiller	Triple effect Vapor Absorption chiller
Cost	Higher base cost due to significant machining content	Proportional to the capacity of the chiller	Proportional to the capacity of the chiller
COP	Full load ~ 1.1 / 1.3 IPLV ~ 1.6 / 1.8	Full load ~ 1.4 IPLV ~ 1.6	Full load ~ 1.8 IPLV ~ 2.1
Range	700 TR – 5000TR	50 TR – 3000 TR	50 TR – 2000TR
Refrigerant	Halocarbons	Water, Environmental friendly	Water, Environmental friendly
Noise Vibrations	105 – 110 db Higher	~ 80 db Lower	~ 80 db Lower
Maintenance	Comparatively high	No moving components, minimal maintenance activities	No moving components, minimal maintenance activities



THANK YOU !

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