Absorption Chiller: Technologies & Applications
Before we begin...

- **Presentation**
  - Emailed to all attendees within 24 hours
  - Posted to [www.gulfcoastcleanenergy.org](http://www.gulfcoastcleanenergy.org)

- **Questions**
  - Submit via Chat Feature
  - Answered via email

- **Continuing Education Units (CEU)**
  - Upon request
Agenda

- Background: Krishnan, US DOE GC RAC
  - DOE Application Center
  - CHP Basics

- Absorption Chillers: Piyush Patel, Thermax
  - Company Overview
  - Product Portfolio
  - Chiller Performance
  - Technical Aspects
  - Applications & Case Studies
  - Multi Energy Chillers
Develop regional strategies to support:

**Combined Heat and Power**

**Waste Heat Recovery**

**District Energy**

1) **Education and Outreach**  
   Website, workshops, webinars

2) **Policy Development Initiatives**  
   Legislative and regulatory issues

3) **Project Specific Support**  
   Audits, feasibility studies, assistance

**Partners:**

U.S. Department of Energy

Gulf Coast Clean Energy Application Center
CHP: Typical Schematic

Fuel input
• Natural gas
• Landfill gas
• Digester gas

Reciprocating Engine
Turbine

Work

Electricity Generator

Electricity

Waste Heat Options

Process Steam
Space Heating
Domestic Hot Water
Industrial process drying
Chilled Water
Additional Electricity

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Gulf Coast Clean Energy Application Center
THERMAX
AN OVERVIEW
Vision

To be a globally respected, high performance organization, offering sustainable solutions in Energy & Environment
Businesses

- Boilers & Heaters
- Air Pollution Control
- Vapor Absorption Chillers
- Specialty Chemicals
- Turnkey Power Plants
- Waste & Waste Water Solutions
Locations
Company Profile

• A 40 year old value based organization
• Manufacturer of Industrial Boilers, Air Pollution Control Equipments, Absorption Chillers and Chemicals
• From $ 0.5 million in 1966 to $ 1B at present
• Total Manpower: 4000
• World wide network of 13 offices, 5 subsidiaries and > 100 distributors/reps
• 50,000 installations for various businesses in more than 75 countries
• World class manufacturing plants (> 1 million square feet)
• Quality assured manufacturing to international codes
• Tradition of intensive R&D
• Thermax: 3rd best company to work for in India: BT Mercer Survey
• Most comprehensive range of absorption chillers
• License agreement - Babcock & Wilcox (for utility boilers)
• Technology and Manufacturing Licensing Agreement – Georgia Pacific Chemicals
• Business tempered by social responsibility
Global Footprint

- Well established sales and service rep network for North & South America, Europe, Middle East, Africa & other markets
- Dominant market share: India, South East Asia, Middle East and Europe
- Respectable player: US and Brazil Markets
- Absorption chillers’ manufacturing facility - ISO 9001: 2000, ISO 14001 and OHSAS 18001 certified
- Absorption chillers comply to ETL, MEA, CE, DIN, ASME, GOST and other international standards
- Absorption chillers inspected by Jacobs, Lloyds, BV, TUV, ASME, SGS & other international agencies
Wholly Owned Subsidiaries

- THERMAX INC. USA (Northville, MI)
- THERMAX EUROPE LTD. (UK)
- THERMAX ZHEJIANG LTD. (CHINA ABSORPTION PLANT)
- THERMAX HONGKONG LTD.
- THERMAX DO BRASIL LTDA.
Overseas Branch Offices

- Bangladesh
- Belgium
- Indonesia
- Kenya
- Malaysia
- Nigeria
- Philippines
- Russia
- Saudi Arabia
- Sri Lanka
- Thailand
- UAE
ABSORPTION COOLING
Product Portfolio

- Steam Driven Chillers
- Hot Water Driven Chillers
- Direct Fired Chiller-Heaters
- Multi Energy Chillers
- Heat Pumps

Capacity Range: 10 TR – 2000 TR

450 chillers per year
## Product Overview

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RANGE (Tons)</th>
<th># OF MODELS</th>
<th>COP</th>
<th>HEAT INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLE STAGE STEAM (SSA)</td>
<td>50-2000</td>
<td>24</td>
<td>0.7</td>
<td>16.8 lb steam/hr/TR (Steam: 14 – 50 psig)</td>
</tr>
<tr>
<td>TWO STAGE STEAM (TSA)</td>
<td>50-2000</td>
<td>26</td>
<td>1.35</td>
<td>8.6 lb steam/hr/TR (Steam: 55-140 psig)</td>
</tr>
<tr>
<td>LOW TEMP HOT WATER (LTA)</td>
<td>20-1150</td>
<td>27</td>
<td>0.75</td>
<td>3.2 gpm hot water/TR (195/185 degF)</td>
</tr>
<tr>
<td>DIRECT FIRED (DFA)</td>
<td>40-1100</td>
<td>20</td>
<td>1.20</td>
<td>10,000 BTU/hr/TR</td>
</tr>
</tbody>
</table>

Medium and High temperature/ high pressure hot water machines are also available.

Largest single chiller of up to 3500 ton available upon request.

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Cycle of Operation
Basic Principle
Low Temp. Hot Water

**CYCLE DIAGRAM**

*hot water driven absorption chillers*

- Dilute Solution
- Refrigerant
- Chilled Water
- Cooling Water
- Hot Water
- Concentrated Solution

- Valve open
- Valve close

Diagram showing the cycle of hot water driven absorption chillers, with labeled components such as Condenser, Absorber, Overflow Pipe, Purge Pump, and Heat Exchanger.
Single Stage Steam
Two Stage Steam

[Diagram showing a two-stage steam system with labels for various components such as low temp generator, drain heat exchanger, high temperature generator, steam inlet, steam control valve, heat reclaimers, and flow of concentrated and intermediate absorbent, refrigerant, and vaporized refrigerant.]
Cooling Cycle

Double Effect Direct Fired Chiller-Heater
Heating Cycle

Double Effect Direct Fired Chiller-Heater
Direct Fired with Side Arm Heat Exchanger
Why two stage is more effective?

- No. of stages indicate how many times, refrigerant is generated (or LiBr is concentrated).
- Heat is required to increase the dilute solution concentration from 59% to 63%.
- In single stage chillers, this heat is supplied by low pr steam in Low Temp Generator and LiBr boils at about 200F.
- In two stage chillers, heat is supplied by high pr. steam in High Temp Generator, where LiBr boils at about 320F & its concentration rises from 59% to 61%. Water vapors separated here further boils the LiBr 61% to 63% in second stage generator. This is possible since the pressure in second stage generator is low and hence the boiling point is also low.
- So external heat source is used only for first stage generation, which is half the total requirement. So heat consumption is half or in other words, COP is double.
Features & Benefits

- Rated in accordance with ARI 560
- Rugged design: Life span > 20 years
- Special on-line concentration measurement & control ensures operating temp is as far as \textbf{18 deg F} away from the crystallization temperature
- Factory mounted vacuum pump
- Part load operation 10 -100%
- Corrosion Inhibitor: Lithium Molybdate
- Chilled water outlet temp: 32 ~70 F
- Cooling water inlet temp: 50 F
- MODBUS communication protocol

- Simple Design – Easy for maintenance e.g.
  - Gravity Feed System (SS),
  - Sight glasses,
  - Isolation valves for refrigerant & solution pumps,
  - Side exit nozzles and Hinged type absorber/condenser headers,
  - Wet back and wet front furnace (no refractory)
Optional Features

- Non-proprietary highest quality parts/raw material e.g.
  - Siemens PLC,
  - Teikoku pumps,

- **OPTIONAL FEATURES:**
- Different tube metallurgy: Cu, Cu-Ni 90/10, 70/30, SS 316L, Titanium
- Various power supply: (208V, 460V, 415V, 380V, 575V) (50 or 60 Hz)
- Factory installed hot & cold insulation
- Auto purging
- Remote CHW set-point (reset)
- Bacnet/ Lonworks communication protocols
- Multi piece shipment
- High pressure headers
- Flameproof construction
- Online bearing monitoring for solution pumps
# Heat sources

<table>
<thead>
<tr>
<th>Form of Heat</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>• Piped Gas connection</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>• Solid fuel/ Bio-mass Boiler</td>
</tr>
</tbody>
</table>
| Low Pressure Steam   | • Used waste steam  
                       | • Process steam                                                       |
| Hot Water            | • Heat recovery heat exchangers  
                       | • Prime movers - Micro-turbines, jacket water of Gas engines, Gas turbines, Fuel cells  
                       | • Solar Collectors                                                     |
Applications

- Textiles
- Chemicals
- Refineries & Petrochemicals
- Electronics
- Engineering
- Pharma
- Paper & Pulp
- Steel
- Commercial Centers
- Power
- Food & Dairy
- Sugar
# Applications

- **COMFORT AIR CONDITIONING**
  - Hotels & Resorts
  - Office
  - Art Gallery/Museum
  - Schools, Universities
  - Supermarkets, Malls
    - Banks
    - Hospital
    - Electronics
    - Apartments

- **PROCESS COOLING**
  - Chemicals
  - Textiles/Garments/Synthetic Fibers
  - Paper
  - Pharmaceuticals
    - Food
    - Printing
    - Plastics
    - Brewery
    - Rubber

- **CHPC/COGENERATION**

- **INLET AIR COOLING**
Ensuring cool summers & warm winters in a high rise commercial building in New York

In one of the most prestigious buildings in the heart of New York city, two 500 TR gas-fired, double effect Thermax absorption chiller-heaters, with side arm heat exchangers, provide cooling during summer and heating during winter. This has not only helped reduce peak electric demand, but also eliminated the need for a boiler.

Supplied in multiple pieces, because of the restricted ingress to the building, these machines were assembled on site. Also, these chillers are very environment-friendly, with the refrigerant being water which has zero ozone depleting potential.
Comfort Cooling

University Campus Cooling using high Temp. hot water

When the old inefficient absorber at the site was replaced by a 1400 TR, two stage, high temperature high pressure hot water driven chiller from Thermax, the effect was felt instantly. Today, the chilled water output is used for air conditioning several buildings on the campus.
For the last 6 years, 6 Thermax stage Gas driven 600 Ton absorption chillers have been providing chilled water for the air conditioning at this largest facility using absorbers in South America. This ensues in Clean & Green Air conditioning for the facilities, saving simultaneously on precious & often scarce electricity.
Passing the test in Ohio
- using waste heat to cool the process

When a leading plastics manufacturer in Ohio hosted a 1100 kW test engine from Waukesha, it was discovered that this test engine also generated a great deal of waste heat. This waste heat was put to productive use, when it was harnessed to drive a 150 TR Thermax absorption chiller. The chilled water output from this absorption chiller is now used for process cooling.
Using heat to cool state facilities

A Thermax chiller keeps the mercury levels down at a state facility in sunny California. Waste heat recovered from the 10 x 60 kW Capstone Micro Turbines (used for peak shaving) is used to drive a 150 ton Thermax low temperature, hot water driven absorption chiller. This, in turn, is used for air conditioning several buildings in the facility.
At a plastics factory in California, three 375 KW natural gas fired engines provide a large part of the electric energy used on the site. The jacket water from these engines was routed to a Thermax single stage 500 ton absorption chiller to produce chilled water. Today, this chilled water output meets the entire cooling requirements of the injection molding process in the company's operations.
CHPC

1000 Ton Low Temp hot water chiller being shipped for a Casino in Atlantic City
Cooling using CHPC route
Solar Based Cooling

30 ton hot water chiller in Spain
What’s new?

Multi- Energy Chillers
Tri-generation

Cooling... (old concept)
Tri-generation

Cooling ... (New concept)
System efficiency
with and without recover

Sankey Diagram* for IC engine

WITHOUT HEAT RECOVERY - 40%

100%

RADIATION LOSS 2%
STACK LOSS WITHOUT HEAT RECOVERY 32%
COOLANT LOSS 25%
ELECTRICAL OUTPUT 40%
MECHANICAL OUTPUT 41%

* Indicative Only

WITH HEAT RECOVERY 75 - 80%

100%

RADIATION LOSS 2%
COOLANT LOSS 7%
STACK LOSS AFTER HEAT RECOVERY 10%
STACK RECOVERY 22%
MECHANICAL OUTPUT 41%
ALTERNATOR LOSS 1%
ELECTRICAL OUTPUT 40%

Heat Recovery - HT Jacket
Water waste heat 18% + Exhaust
Flue gas 22%

NET USEFUL OUTPUT
POWER + PROCESS HEAT & COOLING 80%
Multi-Energy chiller offerings

- Absorption chiller on exhaust gas only (ED Series)
- Absorption chiller on exhaust gas and jacket hot water (EJ Series)
- Absorption chiller on exhaust gas with supplementary / boost-up gas/oil firing (EDG Series)
- Absorption chiller on exhaust gas and jacket hot water with supplementary / boost-up gas/oil firing (EJG series)
## Cooling potential on engine ratings

<table>
<thead>
<tr>
<th>Engine size (kW)</th>
<th>Cooling Capacity* on Exhaust + Jacket water (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>100 ~ 110</td>
</tr>
<tr>
<td>500</td>
<td>175 ~ 200</td>
</tr>
<tr>
<td>1000</td>
<td>300 ~ 350</td>
</tr>
<tr>
<td>1500</td>
<td>425 ~ 500</td>
</tr>
<tr>
<td>2000</td>
<td>525 ~ 600</td>
</tr>
</tbody>
</table>

* Indicative and may vary as per engine waste heat parameters
Advantages

• Custom design to meet the project requirements, thus offering optimum heat recovery and efficiency

• Advanced series flow cycle to avoid simultaneous occurrence of high temp and high concentration thus minimizing possibility of corrosion

• Single chiller on multiple engines without compromising engine safety

• Unique online LiBr concentration measurement and control to keep safe 18F distance from the crystallization line

• Approx. 10% higher heat recovery from the same engine

• Unique feature for chiller safety during long period shutdown
Salient features

• Cooling Capacity range: 50 ton to 2000 ton

• Options available on tube material like copper, Cupro-Nickel, SS 316L, Titanium to suit the water quality available at site

• Auto purging

• PLC based control system

• Online stand by pumps

• Multi-piece shipments
Experience

[Diagram showing various types of engines and machinery, including CAT, Guascor, Rolls Royce, Cummins, Man B & W, Capstone Micro turbine, Hyundai, Waukesha, GE Jenbacher, Deutz, and Wartsila.]
California State University, Fullerton, CA
4.5 MW Power, 2600 TR of Cooling

1 x 4.5 MW CAT Solar Gas Turbine

Exhaust gas

2 x 1300 TR Exhaust Fired Chillers

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IBM Data Center Syracuse University, NY, 780kW Power, 300 TR of Cooling

12 x C65 Capstone Micro - Turbine

2 x 150 TR Exhaust gas Fired Chillers

Exhaust gas

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Gulf Coast Clean Energy Application Center
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Thank You!
Upcoming webinars & Announcements

6/23 – Texas Legislature: Wrap-up

6/30 – Measuring the CHP Advantage

7/14 – Louisiana Legislature: Wrap-up

Go to www.GulfCoastCleanEnergy.org
> News & Events > Webinars

2011 Annual CHP Conference
October 18-19
Westin Hotel Galleria
Houston, TX

- Panel discussions
- Breakout sessions
- Exhibits
- Awards Ceremony
- CHP installation tours
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