Combined Heat and Power and Commercial Operations: Efficiently Cooling Buildings with CHP

Gavin Dillingham, PhD Director Southcentral CHP TAP
April 2020
DOE CHP Technical Assistance Partnerships (CHP TAPs)

- **End User Engagement**
  Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.

- **Stakeholder Engagement**
  Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation’s resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.

- **Technical Services**
  As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.

www.energy.gov/chp
DOE CHP Technical Assistance Partnerships (CHP TAPs)
Outline

- CHP Overview
- CHP in Commercial Buildings
- Project Snapshots
- Thermax Case Study Presentation
  - Abhijit Moholkar – Global Sales Manager at Thermax
- Working with CHP TAP
CHP Overview
Fuel
100 units

CHP
75% efficiency

Power Plant
32% efficiency (Including T&D)

Onsite Boiler
80% efficiency

Total Efficiency
~ 50%

Electricity
30 units

Heat
45 units

Total Efficiency
~ 75%

30 to 55% less greenhouse gas emissions

30 units

Fuel
94 units

56 units

Fuel

Fuel
100 units
CHP System Schematic

**Fuel**
- Natural Gas
- Propane
- Biogas
- Landfill Gas
- Steam
- Waste Products
- Others

**Prime Mover**
- Reciprocating Engines
- Combustion Turbines
- Microturbines
- Steam Turbines
- Fuel Cells
- ORC turbine

**Generator**

**Electricity**
- On-Site Consumption
- Sold to Utility

**Heat Recovery**

**Thermal**
- Steam
- Hot Water
- Space Heating
- Process Heating
- Space Cooling
- Process Cooling
- Refrigeration
- Dehumidification

CHP Technical Assistance Partnerships
SOUTHCENTRAL
Common CHP Technologies and Capacity Ranges

Steam Turbines (50 kW – 250 MW)
- Photo courtesy of Siemens

Microturbines (30 kW – 1 MW)
- Photo courtesy of Capstone Turbine Corporation

Gas Turbines (1 MW – 300 MW)
- Photo courtesy of Solar Turbines

Reciprocating Engines (10 kW – 10 MW)
- Photo courtesy of Caterpillar

Fuel Cells (5 kW – 3 MW)
- Photo courtesy of Verizon Communications

Source: DOE CHP Technology Fact Sheets

*Ranges not drawn to scale.*
Heat Recovery: Absorption Chillers

- Absorption chillers are heat operated refrigeration machines that operate on chemical and physical reactions to transfer heat. The absorption cycle substitutes a physiochemical process for the mechanical compressor used in common refrigeration systems.

- Absorption chillers can be driven with hot water, steam, or prime mover exhaust.

- Absorption chillers are available in sizes from 5 to 3,000 refrigeration tons. This capacity correlates to a CHP electric output of approximately 50 to 10,000 kW.

- For 40°F and higher chilling fluid temperatures (e.g., building air conditioning), a common refrigerant solution mixture is water (refrigerant) and lithium bromide (absorbent). For chilling fluid temperatures below 40°F (e.g., cold storage), a common refrigerant solution mixture is ammonia (refrigerant) and water (absorbent).

A 200-ton single-stage absorption chiller integrated with three 600 kW reciprocating engines that also provide hot water for process and space heating. The system is located at a metal fabrication facility in Fitchburg, Massachusetts. Photo courtesy of Northeast CHP Technical Assistance Partnership (CHP TAP).
What Are the Benefits of CHP?

- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- Higher efficiency **reduces emissions** of pollutants
- CHP can also increase **energy reliability and resiliency** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.
CHP Today in the United States

Existing CHP Capacity

- **81.1 GW** of installed CHP at more than 4,500 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO₂** compared to separate production

Source: DOE CHP Installation Database (U.S. installations as of December 31, 2018)
CHP Additions by Application (2014-2018)

By Installations – 866 Installs

- Other/Unknown: 15 Installs
- Food Processing: 37 Installs
- Other Industrial: 122 Installs
- Colleges/Univ.: 53 Installs
- Hospitals: 58 Installs
- Hotels: 44 Installs
- Wastewater Treatment: 58 Installs
- Schools (K-12): 50 Installs
- Multi-Family: 181 Installs

By Capacity – 3.3 GW

- Other/Unknown: 22 MW
- Chemicals: 553 MW
- Food Processing: 285 MW
- Pulp & Paper: 367 MW
- Refining: 407 MW
- Other Industrial: 494 MW
- Colleges/Univ.: 162 MW
- District Energy: 163 MW
- Utilities: 271 MW

Source: DOE CHP Installation Database (U.S. installations as of December 31, 2018)
New Markets for Packaged CHP

- CHP technology advancements allow for standardized packaged CHP systems
  - Most systems range from 10 kW to 2 MW
- Packaged systems expected to expand the CHP market to new customers
  - Avoid costs and delays associated with customized engineering and design
  - 26 GW of CHP technical potential in the 50-499 kW size range
- Packaged systems are increasingly including solar PV in addition to CHP equipment
- DOE Packaged CHP eCatalog seeks to increase package options up to 10 MW
DOE Packaged CHP eCatalog

- A national web-based searchable catalog (eCatalog) of DOE-recognized packaged CHP systems and suppliers with the goal to reduce risks for end-users and vendors through partnerships with:
  - **CHP Packagers and Solution Providers** that assemble, install, commission and service packaged CHP systems
  - **CHP Engagement partners** that provide CHP market deployment programs at the state, local and utility level
- Pre-engineered and tested packaged CHP systems that meet DOE performance requirements
- End-users and design engineers search for applicable CHP system characteristics, and get connected to packagers, installers and CHP engagement programs
- Allows users to compare technology options on a common basis

https://chp.ecatalog.lbl.gov/
CHP Integration with Renewables & Storage

- **CHP + Solar PV** - solar seldom meets the entire electricity load, making room for CHP to supply thermal loads and electricity when PV electricity is insufficient or unavailable.

- **CHP + Battery Storage** – 1) dampen daily demand swings; 2) Shift power usage from off peak to on-peak periods; 3) enhanced resiliency and availability; and 4) enhance grid value-stacking capabilities (voltage support, T&D deferral, reserve capacity, reliability, over-generation management).

- **CHP in a Microgrid** – 1) efficient measure to serve thermal load; 2) backup power during extended outages; 3) supplements generation from PV & storage.

- **CHP is a Flexible Generation Resource** – most CHP technologies can be powered down or off when renewable supply exceeds demand.

- **CHP Powered by Renewable Gas (biogas, hydrogen)** - would enable CHP to partially or completely utilize renewable fuel either by piping non-pipeline quality biogas to the CHP site; using directed renewable gas; or purchasing pipeline gas that has been blended with renewable gas.
CHP in Commercial Buildings

Microgrids and Resilience
Microgrids
Microgrids Can Incorporate Many Technologies

Microgrids with CHP can produce baseload power 24/7 and continue critical operations indefinitely during extended utility outages

- Efficient operation, emission reductions, reliable fuel supply
- Improved power quality, increased resilience, and potential for ancillary services
CHP Can Enable Other Microgrid Technologies

- With a CHP system providing baseload electric and thermal energy, microgrids can add:
  - Solar and wind resources
  - Energy storage
  - Demand management
  - Central controls
  - Electric vehicle charging

- Flexible CHP systems can ramp up and down as needed to balance renewable loads and provide grid services
Microgrid Implementation Drivers

- End-users choose to install microgrids due to a combination of site-specific factors or *implementation drivers*
  - **Clean Power**
    - Cut emissions through the use of efficient and/or zero-carbon microgrid technologies
  - **Economics**
    - Reduce electricity, heating, cooling, and other costs through various mechanisms, such as self-generation (avoided utility costs), shared operation and maintenance, and lower fuel prices
  - **R&D**
    - Conduct research on new technologies, microgrid configurations, and financing arrangements
Microgrid Implementation Drivers (continued)

- **Reliability & Resilience**
  - Improve electricity and thermal energy reliability and resilience during grid outages and other major disruptive events
  - Especially important for critical infrastructure facilities

- **Remote Grid**
  - Provide power to remote locations that cannot rely on the power grid, such as an island community

- **Renewables Integration**
  - Incorporate renewable technologies into power generation mix while using other technologies to offset the intermittency of renewables
New Business Models: Microgrids as a Service

- Microgrids are complex, with multiple energy resources serving variable loads
  - Custom-engineered logic controller with inverters, relays, and switchgear to respond to loads and utility signals
- Business owners do not understand the complexity
- Large capital investment, multiple parties involved
- Developers are beginning to offer “microgrids as a service”
  - Power purchase agreements with long-term contracts
  - Developers engineer, finance, install, operate and maintain the microgrid
  - Schneider Electric, PowerSecure (Southern Company), Siemens and more
  - Carlyle Group set up Dynamic Energy Networks for this offering, with $500M initial backing
Power Outages are Costly

U.S. 2019 Billion-Dollar Weather and Climate Disasters

This map denotes the approximate location for each of the 14 separate billion-dollar weather and climate disasters that impacted the United States during 2019.
Electric System Disturbances

Electric system outages are increasingly frequent...

And outages are increasingly caused by natural disasters and storm events

Reliability and Resilience: C&I Outage Costs by Sector

Manufacturing facilities generally experience higher outage costs than other Large C&I customer segments.


Resilience Planning with DOE Resiliency Accelerator

- The **DOE CHP for Resiliency Accelerator** includes resources and tools designed to assist with resilience planning efforts
  - Distributed Generation for Resiliency Planning Guide
  - CHP for Resilience Screening Tool
  - Issue Brief on Performance of DERs in Disaster Events
  - Partner Profiles

https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency
# Distributed Energy Resources Disaster Matrix

**Ranking Criteria**

Four basic criteria were used to estimate the vulnerability of a resource during each type of disaster event. They include the likelihood of experiencing:

1. a fuel supply interruption,
2. damage to equipment,
3. performance limitations, or
4. a planned or forced shutdown

<table>
<thead>
<tr>
<th>Natural Disaster or Storm Events</th>
<th>Flooding</th>
<th>High Winds</th>
<th>Earthquakes</th>
<th>Wildfires</th>
<th>Snow/Ice</th>
<th>Extreme Temperature</th>
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<td>Battery Storage</td>
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<td>Biomass/Biogas CHP</td>
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<td>Distributed Solar</td>
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<td>Distributed Wind</td>
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<td>Natural Gas CHP</td>
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<tr>
<td>Standby Generators</td>
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</table>

- indicates the resource is unlikely to experience any impacts
- indicates the resource is likely to experience one, two, or three impacts
- indicates the resource is likely to experience all four impacts


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[CHP Technical Assistance Partnerships](https://www.chp-tech-assist.org)
CHP Meets Power Reliability and Resilience Requirements

- If the CHP system is connected to the grid, it should:
  - Be designed to disconnect and keep operating following a power disturbance, and
  - Should cover the critical loads of the facility.

<table>
<thead>
<tr>
<th>Requirements for Critical Infrastructure Power Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black-start capability</td>
</tr>
<tr>
<td>The CHP system must have an electrical signal from a battery system or onsite backup generator to provide “black-start” capability when there is a grid outage.</td>
</tr>
<tr>
<td>Generator capable of operating independently of the grid</td>
</tr>
<tr>
<td>The CHP electric generator must be able to continue or maintain operation without a grid power signal. High frequency generators (microturbines) or DC generators (fuel cells) need to have inverter technology that can operate independently from the grid.</td>
</tr>
<tr>
<td>Ample carrying capacity</td>
</tr>
<tr>
<td>The facility must match the size of the critical loads to the CHP generator.</td>
</tr>
<tr>
<td>Parallel utility interconnection and switchgear controls</td>
</tr>
<tr>
<td>The CHP system must be able to properly disconnect itself from the utility grid and switch over to providing electricity to critical facility loads.</td>
</tr>
</tbody>
</table>

Project Snapshots
Project Snapshot:
Data Center CHP reducing emissions and operating costs

**Southwestern Energy**
Spring, TX

**Application/Industry:** Computing Facility/Data Center

**Capacity:** 630 kW

**Prime Mover:** Reciprocating Engine

**Fuel Type:** Natural gas

**Thermal Use:** Cooling

**Installation Year:** 2014

**Testimonial:** “Southwestern Energy is dedicated to the safe and environmentally responsible development of energy, and the CHP program has helped us to meet this goal at our Spring, TX campus by an impressive margin. We are obtaining electricity and cooling through the CHP for our 9,000 square-foot data center off-the-grid, while reducing our carbon footprint and overall environmental impact.”

-- Jayme Negvesky, Senior Operations Manager

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**CHP Technical Assistance Partnerships**
SOUTHCENTRAL

*Slide prepared 2/2019*
Project Snapshot: OATI Microgrid Technology Center

Location: Bloomington, MN

Application/Industry: Commercial office building
Capacity: 600 kW
Prime Mover: Microturbine
Fuel Type: Natural Gas
Thermal Use: Space heating and cooling
Installation Year: 2017

Key Characteristics:
To accompany a new corporate campus, including the headquarters and a data center, OATI developed an on-site microgrid to meet its energy needs. Utilizing several technologies, including CHP, solar, wind, storage, and diesel backup generators, the microgrid provides reliable, resilient, and cost-effective power to the campus.

Sources: https://www.oati.com/about/microgrid-technology-center
Project Snapshot:

Power Reliability

Fairway Market Red Hook
Brooklyn, NY

Application/Industry: Retail Space
Capacity: 1 MW
Prime Mover: Reciprocating engine
Fuel Type: Natural gas
Thermal Use: Space heat, domestic hot water, cooling via absorption chiller
Installation Year: 2008

Testimonials:

“Blackouts are a major problem for any supermarket. It’s not only loss of sales, but potential loss of merchandise.”
- Dan Glickberg, Executive Vice President, Fairway Market

“The Red Hook store serves as a notice that there’s no conflict between enterprise and the environment. When done with creativity and innovation, environmentally responsible development yields benefits for the bottom line and the planet.”
- Energy Concepts (part of the site development team)
Project Snapshot: Hospitality/Hotels

The Westin Princeville Ocean Resort Villas
Kauai, Hawaii

Application/Industry: Hospitality/Hotels
Capacity: 1 MW
Prime Mover: 5 x 200 kW microturbines
Fuel Type: Propane
Thermal Use: Absorption cooling and pool heating

Testimonial: “We recognize that the vitality of the resort is directly linked to the vitality of the community where it operates...In addition to doing the right thing for the environment, Westin Princeville Ocean Resort Villas is proud of the economic benefits that our project provided to Kaua‘i’s local contractors and vendors.”
– Denise Wardlow, General Manager, Westin Princeville Ocean Resort Villas

Source: The Westin Princeville Ocean Resort and Villas
Source: Hawaii Business Magazine issued April 2015 “More Efficient Power” By Chris Oliver
Thermax Absorption Chillers and CHP

Abhijit Moholkar – Global Sales Manager at Thermax
ABSORPTION CHILLERS IN CHP APPLICATION IN COMMERCIAL BUILDINGS

WEBINAR – CHP TECHNICAL ASSISTANCE PROGRAM

BY

ABHIJIT MOHOLKAR, SALES MANAGER, THERMAX INC.
HOUSTON
The “Trigeneration / CCHP” Concept

- Trigeneration or combined cooling, heat and power (CCHP), is the process by which some of the heat produced by a cogeneration plant is used to generate chilled water for air conditioning or refrigeration.

- An absorption chiller is linked to the combined heat and power (CHP) to provide this functionality.

Benefits

- Onsite, high efficiency production of Reduced fuel and energy costs
- Lower electrical usage during peak summer demand
- Engine heat can be used to produce steam of hot water for onsite use
- Significant reductions in greenhouse gas emissions
- No harmful chemical pollutants since water is used as the refrigerant
System Efficiency

Overall System Efficiency without Heat Recovery = 40%

Overall System Efficiency with Heat Recovery = 75 - 80%
WHY VAPOUR ABSORPTION CHILLERS?

- **Sustainable Solutions**
  - **For Energy & Environment**

- **Lower Operating Cost**
  - Low on Maintenance Cost

- **Environment Friendly Refrigerant**
  - (Water) “0” ODP & GWP

- **Industry 4.0 Enabled**
  - Smart Manufacturing

- **Substantial Reduction**
  - In Carbon Footprints

- **Waste Heat**
  - Can Drive Absorption Chiller

- **Low Power Consumption**
  - 92% Lower Electrical Consumption than Electrical Chillers

- **No Refrigerant Leakage**
  - No Top Up Requirement
  - No Wear & Tear – Low Down Time

- **Reduced Dependency**
  - Of Power Grid
**BASIC PRINCIPLE**

When maintained at high vacuum, water boils and flash cools itself.

Concentrated LiBr solution has affinity towards water. The solution absorbs vaporized refrigerant.
As LiBr becomes dilute it loses its capacity to absorb water vapour. It thus needs to be re-concentrated using a heat source. This heat causes the solution to release the absorbed refrigerant in the form of vapour. This vapour is cooled at a separate chamber to become liquid refrigerant. The concentrated LiBr is sprayed in absorber.
How it works…

Fundamental Principle : Link

Single Stage chiller : Link

Double stage chiller : Link
Waste Heat Recovery From E+J+ Back Up Firing
TYPES OF HEAT SOURCE

Types of Heat Source

- Steam Driven
- Hot Water Driven
- Vapor Absorption Machine (VAM)
- Exhaust Gas Driven
- Direct Fuel Fired
- Multi Heat Sources
- Thermic Fluid Driven

Multi Energy Multi Utility

- Steam
- Hot Water / Thermic Fluid
- Exhaust Gases
- Gas / Oil Firing (Natural Gas, Diesel & Bio Gas)
- Heating: Primary Heating: Secondary Simultaneous Chiller Heater
- Heating only Heat Pump Up to 170°C Hot
- Heating only Chiller Up to -5°C Chilled
- Chilling: Primary Chilling: Secondary Chiller Heat Pump 90°C Hot Water & 5°C Chilled Water
TYPES OF VAPOUR ABSORPTION MACHINE

Based on Effect
(No of stages of regeneration)

- SINGLE EFFECT COP - 0.8
- SINGLE DOUBLE EFFECT COP - 1.1
- DOUBLE EFFECT COP - 1.5
- TRIPLE EFFECT COP - 1.8

Based on its Utility / Application

- Chiller
- Chiller - Heat Pump
- Vapor Absorption Machine (VAM)
- Heat Pump (Type I)
- Heat Pump (Type II)

Based on Driving Heat Source

- Steam Driven
- Multiple Heat Sources
- Vapor Absorption Machine (VAM)
- Thermic Fluid Driven
- Hot Water Driven
- Direct Fuel Fired
- Exhaust Gas Driven
Cogeneration & Tri-generation Solutions

- Gas Engine
  - Exhaust Only
  - Exhaust + Jacket Water
  - Exhaust + Jacket Water + Backup Gas Firing
  - Jacket Water recovery

- Gas Turbine
  - Exhaust Only
  - Exhaust + Backup Gas Firing

- Micro Turbine
  - Turbine Exhaust

- Steam Turbine
  - Steam backpressure recovery

Heat Recovery
## Options Available

<table>
<thead>
<tr>
<th>Exhaust Gas driven</th>
<th>Exhaust Gas Chiller-Heater (2 pipe system)</th>
<th>Exhaust Gas Chiller with side arm heat exchanger (4 pipe system)</th>
<th>Back up/ boost-up firing option available</th>
</tr>
</thead>
</table>
| • Plain Exhaust Gas driven chillers | • Cooling in summer producing 7°C (44°F) chilled water  
• Heating in winter producing 60°C (140°F) hot water | • Required hot water temp is > 60°C (140°F) OR  
• When simultaneous supply of chilled + HW is required with > 60°C (<=182°F) | • Get desired output even when the prime mover is not running or running on part load |
Co-generation / Tri-generation Experience

- More than 1400 Installations Globally
- 700+ Installations based in Europe
- 500+ District Heating Installations in Europe
- 250+ Turbine Based Installations
- 50+ Cogeneration Projects in USA
- Turbines Handled: Frame V, VI, VII, VIII, IX
DOUBLE EFFECT EXHAUST FIRED ABSORPTION CHILLER

HEAT ENERGY AVAILABLE IN THE FORM OF

- Flue gas from gas engines or diesel engines
- Flue gas from gas turbines
- Flue gas from micro turbines
- Flue gas from fuel cells
- Clean Flue gas from ovens, furnaces, thermic fluid heaters etc.

**E2 SERIES**

- **HEAT SOURCE:** Exhaust Gas
- **INLET TEMPERATURE:** 250°C – 600°C
- **COP:** 1.5
- **CAPACITY:** 50 - 3500 TR

**CAPACITY SCALE**

<table>
<thead>
<tr>
<th>0</th>
<th>100</th>
<th>500</th>
<th>1000</th>
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<th>2250</th>
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MULTI ENERGY ABSORPTION CHILLER

UTILIZES FLUE GAS AT ≥250°C (≥482°F) OR IN COMBINATION WITH ANY OTHER HEAT SOURCE
HEAT ENERGY IN THE FORM OF:

- Gas engine exhaust
- Diesel generator exhaust
- Gas turbine exhaust
- Engine jacket water
- Hot water from solar collectors
- Fuel Cells • Furnaces • Steam • Fuels

E7 SERIES
HEAT SOURCE 1: Exhaust gas
TEMPERATURE: 250°C – 600°C
HEAT SOURCE 2: Hot Water
TEMPERATURE: 80°C - 120°C
COP: 1.1
CAPACITY: 50 - 2500 TR

CAPACITY SCALE

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</table>
HEAT ENERGY AVAILABLE IN THE FORM OF

- Engine jacket water
- Hot water from solar collectors
- Process condensate
- Flue gas recovery from incinerators
- Process heat recovery
- Fuel cells

CAPACITY SCALE

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<td>SERIES</td>
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<td>HEAT SOURCE: Hot Water</td>
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<tr>
<td>INLET WATER TEMPERATURE: 175 – 250 F</td>
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<td>COP: 0.8</td>
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<td>CAPACITY: 180 – 1650 TR</td>
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Absorption chillers Myths and Facts...

<table>
<thead>
<tr>
<th>Myths</th>
<th>Facts</th>
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<tbody>
<tr>
<td>COP is very less hence not viable for operation unless waste heat.</td>
<td>Yes. COP absolute numbers are low compared to electrical chiller. But feasibility depends on cost of fuel. It is very much feasible with waste / cheap heat sources or fuels.</td>
</tr>
<tr>
<td>Absorption chiller can not work below 40°F chilled water</td>
<td>Thermax absorption chillers can be designed for 34°F pure water or 32°F brine as well</td>
</tr>
<tr>
<td>Absorption chillers are prone to crystallization</td>
<td>New technology has completely eliminated crystallization</td>
</tr>
<tr>
<td>Absorption chiller output can not be varied</td>
<td>20-100% stepless capacity modulation</td>
</tr>
<tr>
<td>Absorption technology has not changed for decades.</td>
<td>Major innovations are introduced. Enhanced COP, lower chilled water temperature, heat pump, Chiller heaters to name a few.</td>
</tr>
</tbody>
</table>
SUCCESS STORIES IN COMMERCIAL BUILDINGS
California State University, Fullerton - USA

- 2 nos. x 1300 TR Multi energy absorption chiller
- 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.
- Heat Source: Exhaust Gas + Supplementary Firing. Exhaust gas from turbine is split and fed to two chillers
- Exhaust from 4.4 MW Natural Gas Turbine
- Capable of producing Chilled & Hot Water Simultaneously

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.

Highlight: High Temp difference in Chilled water loop = 13°C (18/5 deg C), which helped change the scheme from two chillers in series to parallel giving great flexibility in operation
University of Central Florida, Orlando Campus:

The UCF Orlando, Florida with campus of spanning 1415 acres. Campus has unique layout with a series of concentric circles

Installation has:

- 1000 TR Multi energy absorption chiller
- Heat Source: Exhaust Gas + Jacket Water
- Exhaust from 5.5 MW Mitsubishi Natural Gas Engine
Hudson Yards, NY, USA

Hudson Yards, USA
(Tri-generation Plant):

- 4 nos. x 664 TR Exhaust + Jacket Water absorption chillers
- Heat Source: Exhaust + Hot water generated by 3.3 MW GE Jenbacher gas engines.

- **Developer:** joint venture by the New York City Department of City Planning and Metropolitan Transportation Authority. Hudson Yards is a whopping $20 Billion project and is spread across 28 acres.
- It is the largest private real estate development in the history of the United States and the largest development in New York City since Rockefeller Center.
HOSPITALITY INDUSTRY

- Borgata Casino Atlantic City
  - 1300 X 2 TR
  - Hot water fired chiller
  - Hot water from Cogen Plant
- Carlyle Hotel Manhattan, New York
  - Steam Fired chillers
  - 300 TR X 3
  - Steam from New York City Grid
- Televisa TV Channel Studio Mexico city
  - 580 TR (San Angel) 400 TR, 500 TR (Chapultepec)
  - Hot water Janbacher Gas engine
HEALTHCARE INDUSTRY

- Hospital Menonita PR
  - Jacket hot water from Siemens Engine
  - 300 TR
- Hospital De-La- Concepcion PR
  - 360 TR
  - Exhaust + Jacket hot water from Janbacher engine

- Applied Medical Research Los Angeles
  - Capstone Micro turbine heat
  - 300 TR
  - Hot water fired chiller
**Cogeneration Tri-generation at Commercial Buildings**

<table>
<thead>
<tr>
<th>Location</th>
<th>Type and Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paramount Pictures, USA</td>
<td>270 TR Hot Water Chiller</td>
</tr>
<tr>
<td>BBC Studios, UK</td>
<td>410 TR Hot Water Chiller</td>
</tr>
<tr>
<td>Revel Casino, USA</td>
<td>1013 TR x 2 nos. Hot Water Chillers</td>
</tr>
<tr>
<td>100 Market Street, Australia</td>
<td>390TR x 3 nos. Exhaust + Jacket water + Gas Backup Driven Chillers</td>
</tr>
<tr>
<td>Garanti Bank, Turkey</td>
<td>380TR x 2 nos. Exhaust + Jacket water</td>
</tr>
<tr>
<td><strong>Chiller-Heater</strong></td>
<td></td>
</tr>
<tr>
<td>Green Gold Complex, Croatia</td>
<td>240 TR x 2 nos. Exhaust + Jacket water</td>
</tr>
<tr>
<td><strong>Chiller-Heater</strong></td>
<td></td>
</tr>
</tbody>
</table>
Cogeneration Tri-generation at Educational Institutes

- **Salem Community College, NJ, USA**: 160 TR Jacket water + Natural Gas Backup Driven Chillers
- **University of Toledo, Ohio, USA**: 96 TR cooling + 275kW heating; Exhaust Chiller-Heater
- **Shanghai Tech Univ, China**: 1000 TR x 5 nos. Exhaust
- **University of Central Florida, USA**: 1000 TR Exhaust + Jacket water
- **Syracuse University, USA**: 2 nos. x 150 TR Exhaust Chiller
Istanbul Airport, Turkey

Istanbul Atatürk Airport, Turkey:
- Two Absorption chiller-heaters for comfort cooling application.
- Each Chiller-heater to provide **560 TR chilling & 890 kW heating**
- Heat Source: Exhaust + Jacket Water from a 2000 kW x 2 nos. MWM gas Engines

- Owner: Turkish Airlines
- Biggest airport in Turkey and Europe's 5th busiest airport.
- Thermax chillers at three other major airports in Europe – Rome (Italy), Berlin (Germany), Bologna (Italy)
- Turkish Airlines – Cargo Terminal
Cogeneration Tri-generation at International Airports

- **Leonardo da Vinci International Airport, Rome Airport, Italy**: 2000 TR (Total – 3 nos.) Hot Water Chillers
- **Venice Marco Polo Airport, Italy**: 350 TR x 2 nos. Hot water Driven Chillers
- **Berlin Brandenburg Airport, Germany**: 540 TR x 2 nos. Exhaust Driven Chillers
- **Perth Airport, Australia**: 600 TR x 2 nos. Exhaust + Jacket water Driven Chillers
- **Bologna Guglielmo Marconi Airport, Italy**: 240TR x 1 no. Hot water Chillers
Citibank Data Centre, UK

Owner: Citibank Datacenter
Developer : Clarke Energy,

- Trigeneration system at Lewisham (London) data center
- To cut the facility’s energy use by 10 per cent while generating almost three quarters of its own power.
- CCHP system to generate 71% of the electricity needed to power the data centre (23,680 MWh) while also providing cooling for the servers.
- Project is the first of its kind at a UK data centre.
- To drastically reduce Citi’s operating costs and its greenhouse gas emissions.

Highlights: First project in the financial services sector backed by the UK Green Investment Bank (GIB).
Cogeneration Tri-generation at International Data Centers

IBM Datacenter, Syracuse, USA : 100 TR Exhaust + Jacket water + Gas Backup Driven Chillers
Citibank Datacenter, London, UK : 305 TR x 2 nos. Hot Water Chillers
PSECU, Philadelphia, USA : 300 TR Exhaust + Jacket water + Gas Backup Driven Chillers
IBM Mathworks, USA : 100 TR Exhaust + Jacket water + Gas Backup Driven Chillers
University of Toledo, USA 100 TR Hot Water Chiller
CONTACT: ABHIJIT MOHOLKAR
SALES MANAGER, THERMAX INC. HOUSTON
Abhijit.Moholkar@thermaxglobal.com
+1-281-906-3490
How to Implement a CHP Project with the Help of the CHP TAP
CHP TAP Role: Technical Assistance

**Screening and Preliminary Analysis**
- Quick screening questions with spreadsheet payback calculator; Advanced technical assistance to explore equipment or operational scenarios.

**Feasibility Analysis**
- Perform 3rd Party reviews of site feasibility assessments: Estimates on savings, installation costs, simple paybacks, equipment sizing, and type.

**Investment Grade Analysis**
- Perform 3rd Party reviews of Engineering Analysis. Review equipment sizing and choices.

**Procurement, Operations, Maintenance, Commissioning**
- Review specifications and bids.
CHP Databases

DOE CHP Installation Database
(List of all known U.S. CHP systems)

EPA dCHPP (CHP Policies and Incentives Database)

energy.gov/chp-installs

www.epa.gov/chpdchpp-chp-policies-and-incentives-database
CHP Resources

DOE CHP Technologies
Fact Sheet Series

www.energy.gov/chp-technologies

State of CHP Pages

https://www.energy.gov/eere/amo/state-chp-all-50-states-fact-sheet-series
CHP Project Resources

DOE Project Profile Database

DOE Policy/Program Profiles

energy.gov/chp-projects

energy.gov/chptap
Next Steps

Resources are available to assist in developing CHP Projects.

Contact the Southcentral CHP TAP to:

▪ Perform CHP Qualification Screening for a particular facility
▪ Identify existing CHP sites for Project Profiles
▪ Additional Technical Assistance
Summary

- CHP is a proven technology in commercial buildings providing energy savings, reduced emissions, and opportunities for resilience
- Emerging drivers are creating new opportunities to evaluate CHP and numerous example exist to learn more how other commercial buildings have incorporated CHP
- Engage with the US DOE Southcentral CHP TAP to learn more about the technical assistance offerings in evaluating CHP in your commercial building
Thank You!

Gavin Dillingham, PhD
HARC
gdillingham@harcresearch.org
281-364-6045