Microgrid Absorbers Designed for Maximizing Waste Heat Recovery

Combined cooling heating and power.
Modern Absorption. CHP

Case Studies:
Pinellas County Jail & Montgomery County Micro grid

BROAD U.S.A. INC.
Keywords: Combined cooling heating and power. Modern Absorption. CHP

This presentation will cover the absorber design as well as few additional types of absorbers that are available and specifically designed to recovery heat from internal combustion engines.

As engines are being designed to higher and higher electrical efficiencies absorber now can recovery these larger delta T’s and send back even lower temperature to the radiator block.

Double lift & Triple lift as well as steam and exhaust fired combination units to fully capture waste heat steams and improve overall plant COP.
Outline

- CHP & Microgrid
- Modern Absorption Chiller
- Case Studies
- Q & A
CHP / CCHP & Microgrid

Cogeneration or combined heat and power (CHP) is the use of a heat engine or power station to generate electricity and useful heat at the same time.

Trigeneration or combined cooling, heat and power (CCHP) refers to the simultaneous generation of electricity and useful heating and cooling from the combustion of a fuel or a solar heat collector.

Microgrid -- A local power system (a power system on its own), Can operate in interconnected or/and isolated states. Can take part of a Smart grid or not, but it can be smart too. Scalability.

CHP / CCHP : The Foundation of a Microgrid

- Form of Distributed Generation (DG)
- An Integrated System
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for: Space Heating / Cooling o Process Heating / Cooling o Dehumidification
CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs

Power Plant
32% efficiency (Including T&D)

Onsite Boiler
80% efficiency

Total Efficiency ~ 50%

Total Efficiency ~ 75%

30 to 55% less greenhouse gas emissions
CCHP (Trigeneration) System Schematic
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 enhance power quality.
Why Microgrids?

An existing concept updated by technological advances and market conditions.
Modern Absorption Chiller

-- 30 to 3300 ton
-- COP = 1.4-1.52
-- Auto vacuum Purge
-- 24/7 monitoring
-- Multi energy driven (above 180F)
# Modern Absorption Chiller - Titanium Tubes

![Image of titanium tubes]

<table>
<thead>
<tr>
<th>Tube Materials</th>
<th>Solution Media</th>
<th>Pure Copper</th>
<th>Copper-Nickel</th>
<th>Stainless Steel</th>
<th>Titanium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clorine</td>
<td>Resist corrosion under low temp &amp; low concentration</td>
<td>Resist corrosion under low and medium temperature</td>
<td>Resist corrosion differs by types of stainless steel</td>
<td>No corrosion</td>
<td></td>
</tr>
<tr>
<td>salt water (speed)</td>
<td>1.2 m/s</td>
<td>3.6 m/s</td>
<td>5-7 m/s</td>
<td>No limitation</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>Serious corrosion</td>
<td>Corrosion</td>
<td>No corrosion</td>
<td>No corrosion</td>
<td></td>
</tr>
<tr>
<td>Polluted air &amp; water</td>
<td>Corrosion</td>
<td>Slight corrosion</td>
<td>No corrosion</td>
<td>No corrosion</td>
<td></td>
</tr>
</tbody>
</table>
Modern Absorption Chiller - Stainless Steel Plate Heat Exchangers

Plate Heat Exchanger for economizers
316L Plates, Nickel alloy is solder.

- No copper in plate heat exchanger, no corrosion.
Modern Absorption Chiller – 100% performance test
Modern Absorption Chiller – 24/7 monitoring

The Absorbers are monitored by the Central Control System which automatically alerts the service center/executives in the event of a fault with full diagnosis capability.
Modern Absorption Chiller – The magical of hot water

Cooling

Heating

Normal Hot water chiller
Two stage host water chiller
Double lift hot water chiller
Triple lift hot water chiller
Heat Pump I
Heat Pump II
Heat exchange unit

Hot water driven chiller
Modern Absorption Chiller – The magical of hot water

Two stage Hot water driven chiller

Triple Lift hot water chiller

Normal Hot water driven chiller

Double lift hot water driven chiller

90 °C 194F
80 °C 176 F
70 °C 158F
60 °C 140F
55 °C 131F
# Modern Absorption Chiller – The magical of hot water

<table>
<thead>
<tr>
<th>NO.</th>
<th>Type</th>
<th>Structure</th>
<th>COP</th>
<th>Hot Sauces In/Out</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal Type</td>
<td>Normal Single stage</td>
<td>0.76</td>
<td>208/190 °F (98/88 °C)</td>
<td>Standard Price</td>
</tr>
<tr>
<td>2</td>
<td>Two Stage</td>
<td>Identical on Left &amp; right</td>
<td>0.7</td>
<td>194/158 °F (90/70 °C)</td>
<td>1.5 more</td>
</tr>
<tr>
<td>3</td>
<td>Double Lift</td>
<td>Add One generator and absorber</td>
<td>0.45</td>
<td>167/131 °F (75/55 °C)</td>
<td>1.66 more</td>
</tr>
<tr>
<td>4</td>
<td>Triple Lift</td>
<td>Add Two generator and absorber</td>
<td>0.55</td>
<td>194/131 °F (90/55 °C)</td>
<td>1.95 more</td>
</tr>
</tbody>
</table>

Nashville Tennessee... North America’s first triple lift single stage hot water industrial heat recovery from tire manufacturing 185 to 127 °F hot water
Modern Absorption Chiller – The magical of hot water
Case Studies - Pinellas County Jail
Case Studies - Pinellas County Jail

**System Info:**
LOCATION: Pinellas County, Florida

**Generator**
Model: CAT G3516H  
Maximum Continuous Rating: 2027 kW  
Fuel Type: Natural Gas  
Maximum Electrical Efficiency: 44.70%  
Frequency: 50 / 60 Hz  
RPM: 1500 / 1800 rpm

**Absorption Chiller**
Model: BZHE300  
Cooling capacity (CHP) only: 479 ton  
Cooling capacity (NG Max ton): 992 ton  
Exhaust Temp. : 747F  
Exhaust Heat Input: 231,151 lbr/hr  
Cooling Capacity in Exhaust: 299 ton  
COP on Exhaust Heat: 1.33

Hot Water Temp. : 210F  
Hot Water Flow Rate: 322 GPM  
Cooling Capacity in Hot Water: 180 ton  
COP on Hot water: 0.76

Fuel Type: Natural Gas  
Gas Consumption: 8383 MBH  
Cooling Capacity: 992 ton  
COP on Hot water: 1.42
Case Studies - Pinellas County Jail

Installed in 2018, the CHP system is comprised of one CAT G3516H engines (2 MW) with a 1000-ton BROAD absorption chiller. The recovered heat energy (Exhaust & Jacket Water heat) from the engines goes to power the absorption chiller. The BROAD unit has total 479-ton capacity operating on the heated jacket water (180 ton) and exhaust heat (299 ton) from the engines. BROAD chiller also loaded with a gas burner system to produce maximum 1000 ton cooling.

During normal business hours, the system operates at full capacity, providing approximately 2 MW for the building’s electrical loads and the absorption chiller supplying a portion of the building’s cooling requirements. A chilled water plant, composed of two additional electric chillers (total of 2,000 tons), supplies the remaining building cooling needs.

The CHP system produces a combined electrical and thermal efficiency of approximately 78%. During the day, the absorption chiller is able to meet 80-100% of the building’s requirement, thereby allowing the electric chillers to be turned off. Night time overall system efficiency is approximately 65%.

**ANNUAL ENERGY SAVINGS:** $700,000-$800,000

**PAYBACK:** 5 years

**CHP IN OPERATION SINCE:** 2018
Case Studies - Pinellas County Jail
Case Studies - MGM National Harbor
MGM National Harbor is the premier entertainment destination located on the banks of the Potomac just outside of Washington DC. Featuring a 3,000 seat Theater, 308 luxurious hotel rooms, restaurants from acclaimed chefs and a gaming floor bigger than the White House. MGM installed combined heat and power (CHP) in 2016 and an estimated 4.5-year payback.

Why use Cogeneration — Casinos require simultaneous heating, hot water and cooling for HVAC. The CHP provides additional economic savings by using the recovered heat for building heat in the winter and to power an absorption chiller for cooling in the summer.

1) More affordable to operate the facility than an electric Grid Supplied power system  
2) CCHP will typically use 35% less energy.  
3) Significantly Lower CO2 emissions  
4) Resiliency: CCHP system typically can keep facility open during an electric Grid power outage with standard emergency generators  
5) Capital Investment can be paid back within a few years of operation and easily financed

The Chiller system is comprised of 6 magnetic bearing chillers and one 250 ton multi energy (exhaust + jack water) absorption chiller. Building installed four 2.5MW engines running on natural gas and one of engine’s exhaust / jacket water loop connected to exhaust boiler and a 250 ton absorption chiller. During the summer, partial recovered heat is used to power the absorption chiller, providing space cooling.

MGM started CHP operation in July 2017, and now runs the system 24/7. CHP supplies 2.5MW to the facility. The CHP system operated in island mode for few months, until a 3-way exhaust damper failure on November of 2017. MGM’ goal is to generate close to 100% of the facility’s electrical needs, operating in parallel and synchronized to the utility.
Case Studies - MGM National Harbor

System Info:
LOCATION: 101 MGM National Avenue Oxon Hill, MD 20745

**Generator**
Model: CAT 3516C
Maximum Continuous Rating: 2500 kW
Fuel Type: Natural Gas
Maximum Electrical Efficiency: 44.70%
Frequency: 60 Hz
RPM: 1800 rpm

**Absorption Chiller**
Model: BHE77
Cooling capacity (CHP): 258 ton
Exhaust Temp.: 917°F
Exhaust Heat Input: 9,795 lbr/hr
Cooling Capacity in Exhaust: 181 ton
COP on Exhaust Heat: 1.41

Hot Water Temp.: 195°F
Hot Water Flow Rate: 175 GPM
Cooling Capacity in Hot Water: 77 ton
COP on Hot water: 0.72
Case Studies - MGM National Harbor
Case Studies - Pinellas County Jail
## Summary of Absorption Chiller Attributes for CHP Systems

<table>
<thead>
<tr>
<th>Size range</th>
<th>5 to 3,300 refrigeration tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Heat</td>
<td>Hot water, steam, or prime mover exhaust</td>
</tr>
<tr>
<td>Configuration</td>
<td>Available in single (double or triple lift) and two stage designs.</td>
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<tr>
<td></td>
<td>Single stage machines can be driven with hot water (167-240°F) or low pressure steam (15 psig) and are often used with reciprocating engine CHP installations.</td>
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<tr>
<td></td>
<td>Compared to single stage chillers, two stage machines require higher temperature hot water (e.g., 280 - 350°F) or higher pressure steam (e.g., 115 psig) and are often used with combustion turbine CHP installations.</td>
</tr>
<tr>
<td></td>
<td>In addition to hot water and steam, absorption chillers can also be exhaust fired (required exhaust temperatures typically above 650°F).</td>
</tr>
<tr>
<td>Refrigerant / Absorbent</td>
<td>For 39°F and higher chilling fluid temperatures (e.g., building air conditioning), a common mixture is water (refrigerant) and lithium bromide (absorbent).</td>
</tr>
<tr>
<td></td>
<td>For chilling fluid temperatures below 39°F (e.g., cold storage), a common mixture is ammonia (refrigerant) and water (absorbent).</td>
</tr>
</tbody>
</table>
Lessons to Share

1) Negotiate utility contracts including natural gas supply (preferably long term), natural gas delivery, standby rates, and interconnection contracts.

2) Picking a contractor for operation and maintenance is important. On-site engineering staff should have been better trained in the operations of the CHP system.

3) Space to locate the absorption chiller close to the engine units.

4) CHP + Absorption chiller good for base load. Absorption chillers have significant space conditioning requirements or year-round cooling loads. Sites that may require steady year-round cooling include manufacturing plants with process cooling needs, cold storage warehouses, data centers, and district energy plants.
Q&A

Thank You For Your Precious Time

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About BROAD U.S.A.
BROAD U.S.A. is a privately held company Headquarter in New Jersey supporting the sales and service to our Customers in North America. BROAD Absorbers are currently operating successfully in over 80 countries with over 35,000 installations worldwide. Broad is the world largest manufacturer of absorption chillers ranging in size up to 3300 tons.