
Photo by Chuck Berray

Alaska Energy Authority

Absorption Chilling 101
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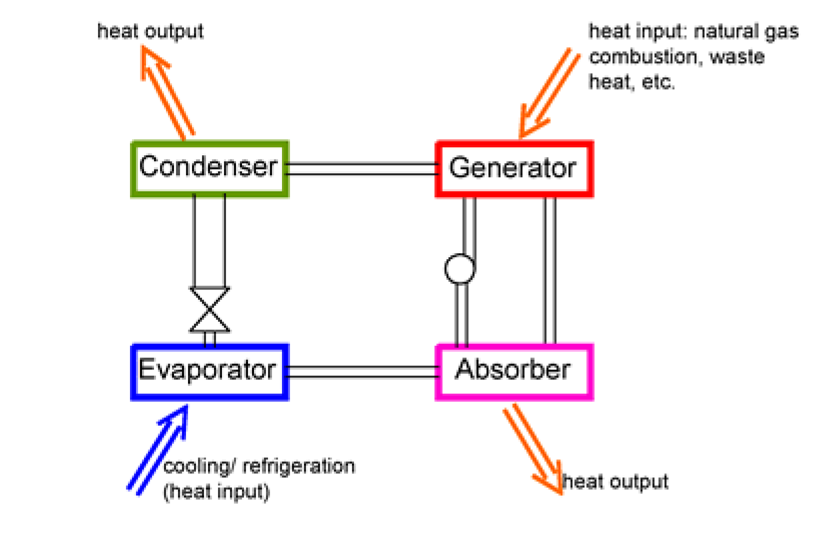
Learning Objectives

Understand:

- the basic operation of an Absorption Chilling
- the potential applications and benefits for this technology
- What important questions to ask when talking with equipment dealers.

What is Absorption Chilling

- A Technology that uses a low grade heat source to generate cooling.
  - Propane refrigerator in a motorhome
- Thermo-chemical process instead of mechanical compression
  - Usually require less than 20% of the electrical energy required by mechanical compression refrigeration systems.
- Requires a heat sink such as a cooling tower to extract heat from the process.
- Most systems use water and either ammonia or lithium bromide
- Coefficient of Performance
  - Single Effect - .7
  - Double Effect – 1.2



Where is Absorption Chilling Used?

- Facilities with a large cooling load and a very inexpensive heat source – free is good!
  - Waste heat recovery from diesel generators
  - Industrial heat sources
  - Steam heating systems
- Large facilities (hospitals/universities, etc.) with steam systems or sources of waste heat have used absorption chillers for their cooling needs for many years.
- Uses
  - Refrigeration
  - Air Conditioning/space cooling
  - Ice Making
  - Cold Storage

Absorption Skid at the Auction Block Seafood Processing Plant in Homer

Photo by Walk Kollenberg

Absorption Chilling Scale

- Sizing – based on Tons of Refrigeration
  - Typical residential air conditioning system is up to 5 TR.
  - Large Commercial systems range from 100 – 1000 TR.
  - Small Commercial systems are available from 5 – 100 TR
- Capital Costs Examples
  - 20T Chiller only - $300,000
  - 130T Chiller only - $650,000
  - Also requires Cooling Tower, heat exchangers, extensive piping, controls
- Can use heat sources as low at 165°F.
- Can produce cooling temperatures as low as -40°F
- Experienced engineer required

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Kotzebue, Alaska Ice Maker

- Energy Concepts 20T Thermochiller – Ammonia Based
- Powered by 165°F Diesel Generator Recovered Heat
- Produces 0°F refrigeration and 15 tons per day of Flaked Ice
- Capital Cost for Chiller/Installation - $280,000
- Electrical costs in Kotzebue - ~$.40/kWh
- Ice is sold in the summer to the fishing fleet.

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Chena Hot Springs, AK – Aurora Ice Museum

- Energy Concepts Double Lift Absorption Chiller
- 16T of -5°F Refrigeration
- Heat Source - 165°F geothermal resource
- "Cooling Tower" – cold water river
- Thermal Storage
- Economics
  - Vapor Compression Chiller (Back-up) – 148 hp
  - Absorption Chiller – 44 hp total
  - 70% reduction in fuel costs ($.30 kWh)

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Pinecrest Medical Care Facility – Power, MI

- Wood Chips Biomass System heats 170,000 sq. ft. facility
- 2800 tons per year of green chips
- Trane Absorption Chillers cools water to 42 °F for 144,000 sq. ft.
- $10,000/month savings over natural gas in 2014.
- System maintenance about 1 hour per day – twice that of a natural gas boiler

Biomass for Residential Scale Cooling?

- Agricultural Utilization Research Institute released a Feasibility Guide for Biomass Cooling in 2016.
- Considered economics based on residential scale BSH Pellet Boilers, Yazaki Absorption Chillers and Thermax Absorption Chillers.
- Pellets showed an annual savings of $758 over electricity and $769 over propane
- Small Scale technology is emerging.

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Conclusions

- Absorption Chilling requires an inexpensive heat source.
- Projects of new construction or retrofits with existing water piping systems are more likely to be economically viable.
- Small scale commercial and residential systems are becoming more available.
- Biomass fueled commercial scale absorption chilling is a growing opportunity.

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- **An absorption chiller has a very straightforward operation**. Its operation is fundamentally similar to what happens in a vapor compression chiller in that both processes involve condensation and evaporation of the refrigerant within the system. However, while an absorption chiller uses a thermo-chemical process, a **conventional chiller relies on mechanical energy**.
- Simply put, **the absorption chiller does not compress refrigerant vapor**; instead, it dissolves the vapor in an absorbent, and transfers the resulting product to higher-pressure environment using a pump with a very low electricity consumption. Of course, this only a description of the basic absorption cycle —there are more complex cycles that even have extra components—.

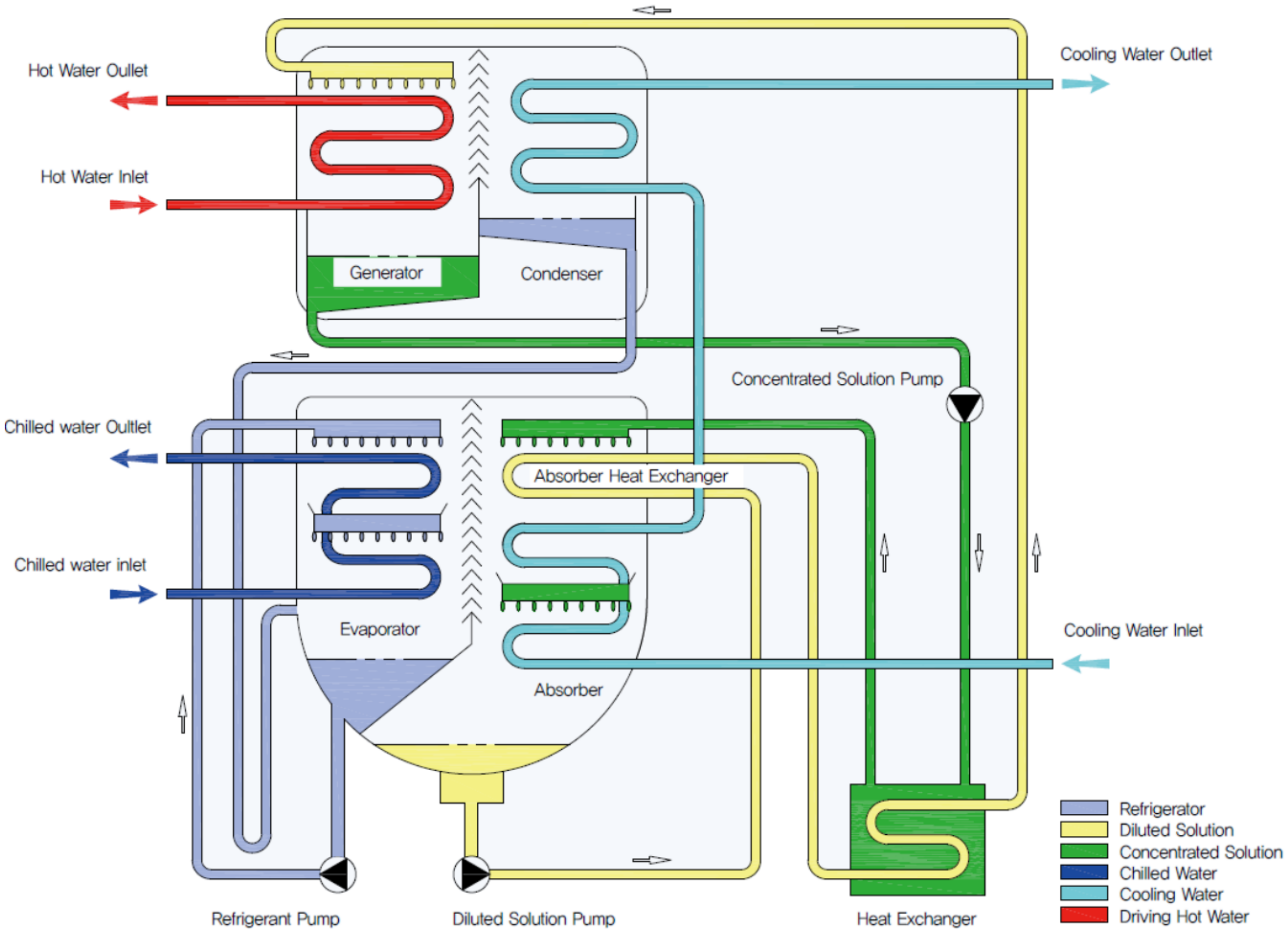
- **Generator:** in the generator, a heat source produces ammonia vapor from a strong ammonia solution. Before the ammonia (refrigerant) vapor enters the condenser, it passes through a rectifier for dehydration.

- **Condenser:** the now dehydrated and high-pressure ammonia enters the condenser where it is condensed. After cooling, it goes through a throttle valve (expansion valve) and pressure and temperature is reduced. The new values must be below what the evaporator (next stage) maintains.

- **Evaporator:** the evaporator, which is essentially the cold refrigerated space, appears now. The cooled ammonia enters the evaporator, absorbs heat and then leaves as saturated ammonia vapor.

- **Absorber:** as the vapor enters the absorber, it is exposed to a spray of weak ammonia-water solution. The weak solution in turns becomes a strong solution. The pump directs the new solution to the generator through the regenerator (may also be referred to as heat exchanger). By the time the solution arrives, it has already attained generator/condensing pressure. The process starts again.

SINGLE EFFECT HOT WATER DRIVEN ABSORPTION CHILLER



Principles of Operation

- An absorption cooling cycle relies on three basic principles:
  - When a liquid is heated it boils (vaporizes) and when a gas is cooled it condenses
  - Lowering the pressure above a liquid reduces its boiling point
  - Heat flows from warmer to cooler surfaces.
- Absorption cooling relies on a thermochemical "compressor.“
  - Two fluids – a refrigerant and an absorbent - have high "affinity" for each other. The refrigerant—usually water—can change phase easily between liquid and vapor and circulates through the system.
- A heat source drives the process. The high affinity of the refrigerant for the absorbent (usually lithium bromide or ammonia) causes the refrigerant to boil at a lower temperature and pressure than it normally would and transfers heat from one place to another.