



# ***Geothermal Powered Absorption Chiller***

*presented by:*

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**Chena Hot Springs Resort**

2005 GeoPowering the West Workshop

Nome, Alaska

June 28<sup>th</sup>, 2005



*'Hot Springs builds Ice Hotel'*  
**Resort Chills Ice Hotel  
with Hot Water**

-- The Tonight Show with Jay Leno

# AURORA ICE MUSEUM



1<sup>st</sup> Aurora Ice 'Hotel' completed in January, 2004 ...



# AURORA ICE MUSEUM



**1st Aurora Ice 'Hotel' melted in June, 2004 ...**

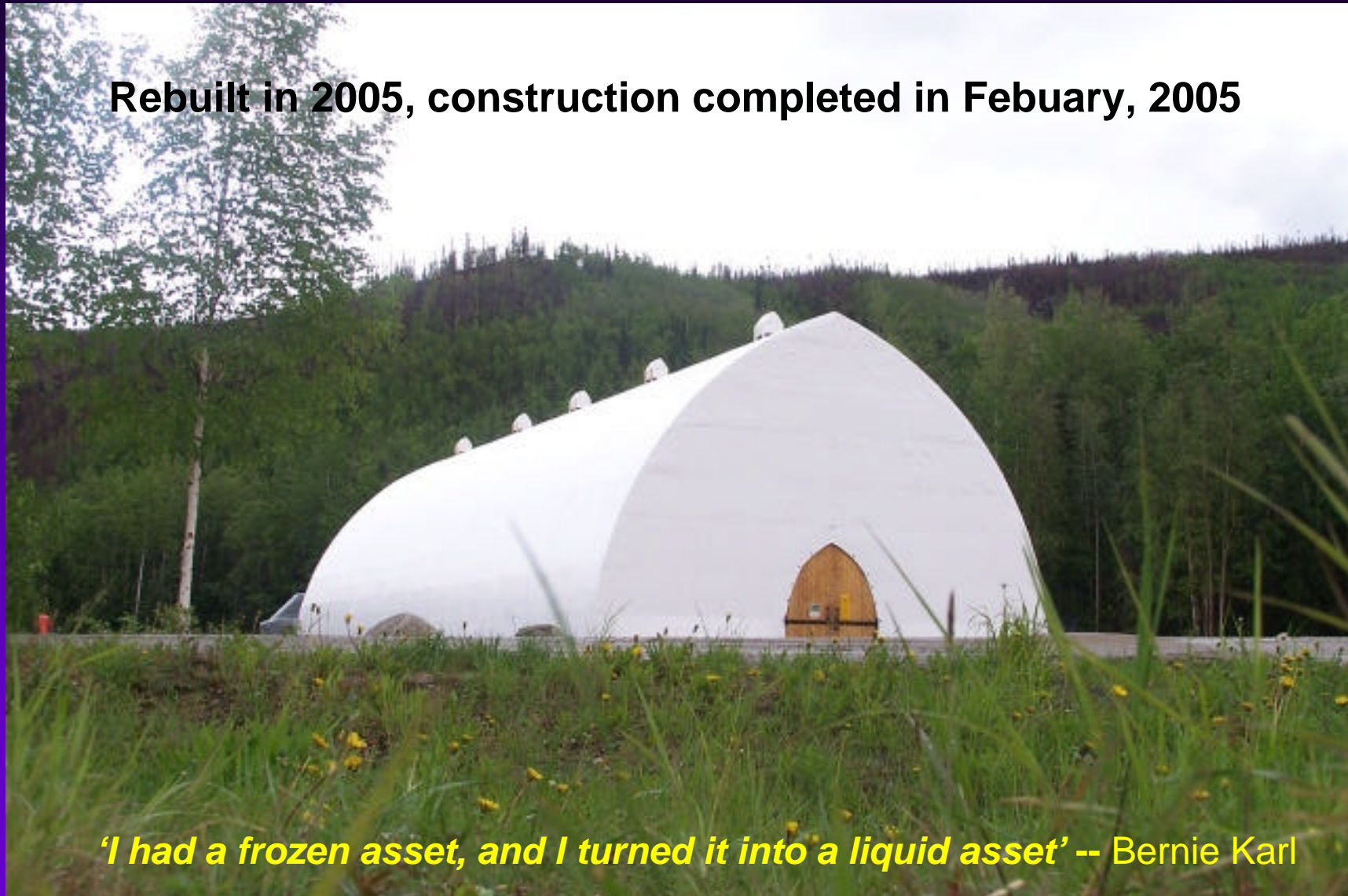




# AURORA ICE MUSEUM



**Rebuilt in 2005, construction completed in Febuary, 2005**



*'I had a frozen asset, and I turned it into a liquid asset' -- Bernie Karl*



# AURORA ICE MUSEUM



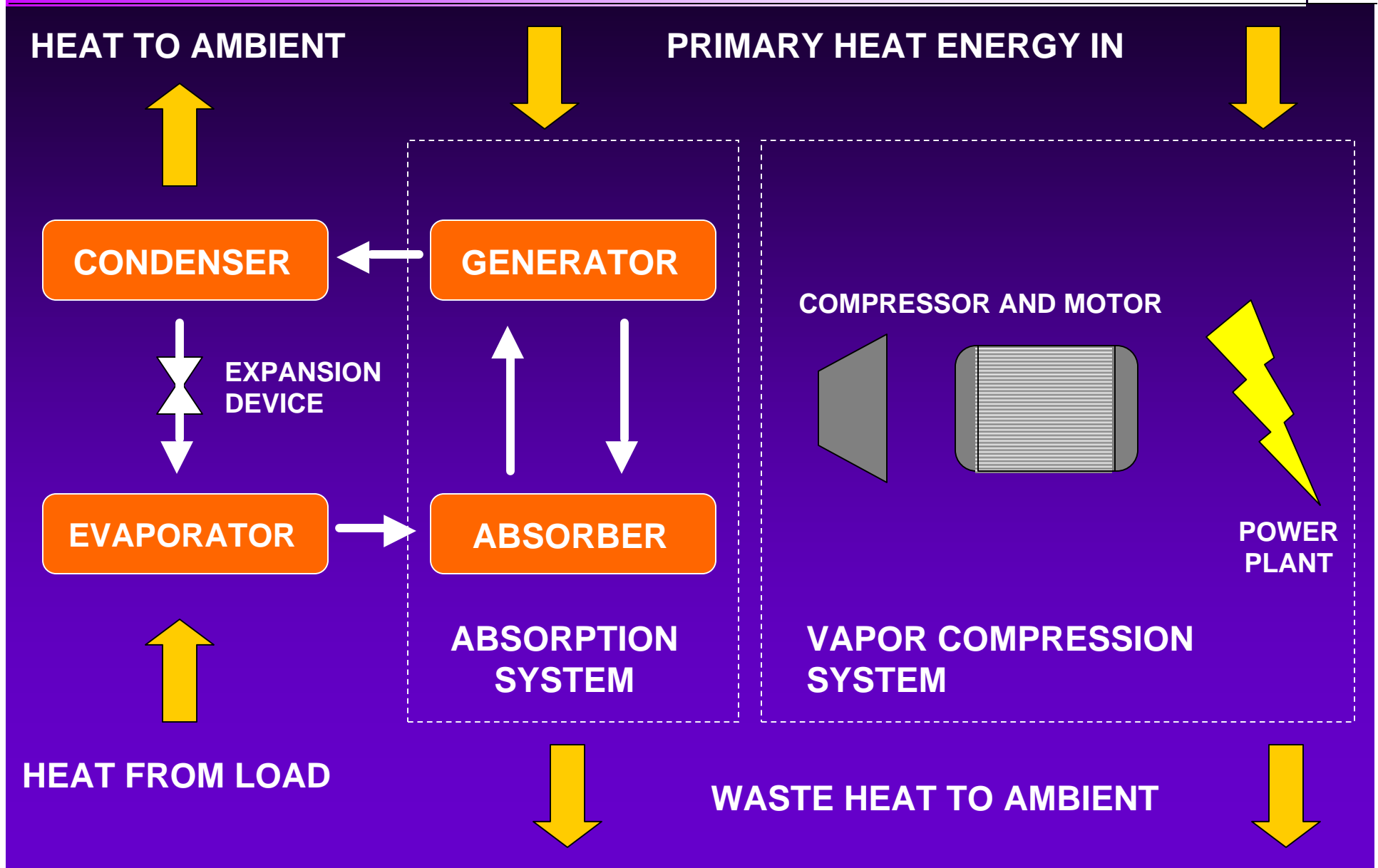
# ABSORPTION REFRIGERATION BASICS



**An absorption refrigeration cycle removes heat through evaporation of a fluid (refrigerant) at low pressure and the rejection of heat through the condensation of a fluid (refrigerant) at a higher pressure**

- Ammonia absorption cycle invented by Ferdinand Carre in 1846
- Efficient when a waste heat source is available, including: Geothermal, Exhaust from Generators, Solar
- Absorption systems have few or no moving parts
- Generally has low thermal efficiency and therefore most economical if used to take advantage of a waste heat source or in a remote location where power is expensive or not readily available

# COMPARISON OF REFRIGERATION CYCLES





# COMPARISON OF REFRIGERATION CYCLES



HEAT TO AMBIENT



CONDENSER



EXPANSION  
DEVICE

EVAPORATOR



HEAT FROM LOAD

Both vapor compression and absorption refrigeration cycles accomplish the removal of heat through the evaporation of a refrigerant at a low pressure and the rejection of heat through the condensation of the refrigerant at a higher pressure.

# VAPOR COMPRESSION SYSTEM



HEAT TO AMBIENT



CONDENSER



EXPANSION  
DEVICE

EVAPORATOR

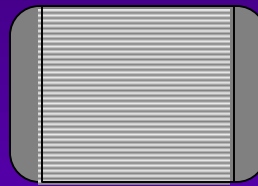


HEAT FROM LOAD

HEAT ENERGY IN



COMPRESSOR AND MOTOR



POWER  
PLANT

VAPOR COMPRESSION  
SYSTEM

Mechanical  
compressor  
used to create  
the pressure  
differences  
necessary to  
circulate the  
refrigerant

WASTE HEAT TO AMBIENT



# ABSORPTION REFRIGERATION SYSTEM



HEAT TO AMBIENT



CONDENSER



EXPANSION  
DEVICE

EVAPORATOR



HEAT FROM LOAD



HEAT ENERGY IN

GENERATOR



ABSORBER

ABSORPTION  
SYSTEM

WASTE HEAT TO AMBIENT



In the absorption system, a secondary fluid or absorbent is used to create a pressure differential and circulate the refrigerant

# KOTZEBUE ICE MAKER



- Installed in 1992 to provide ice for commercial salmon catch
- Single stage ammonia/water system
- Uses waste heat -- cooling water from diesel generator (192F)
- Delivers 10F cold storage (ice)





# O.I.T. ABSORPTION CHILLER



## Geothermally Operated Li-Br Absorption Chiller at O.I.T.

- Installed in 1980 to supply a base cooling load to five campus buildings totaling ~277,000ft<sup>2</sup>
- Installation cost was \$171,300
- Single Stage Lithium Bromide System
- 150 Ton operational capacity
- Used 685 GPM of Geothermal Fluid at 192F
- Decommissioned in 1999 and replaced with a centrifugal water chiller due to low efficiency and high water use

# CHENA HOT SPRINGS ABSORPTION CHILLER



## Absorption Unit Specifications



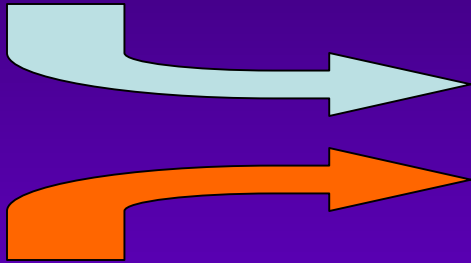
<b>Heat Source</b>	Hot Springs of 165 °F
<b>Creek Water Temp.</b>	40 °F (4.4 °C)
<b>Required Brine Temp.</b>	-21 °F (-29.4 °C)
<b>Required Capacity</b>	16 - RT
<b>Size</b>	4ft x 4ft x 6ft

**Designed and Built by Energy Concepts Co  
Annapolis, MD**

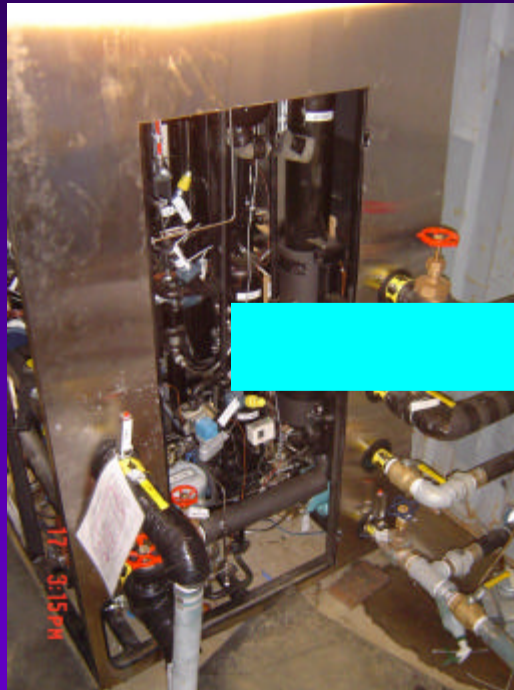
# CHENA HOT SPRINGS ABSORPTION CHILLER



Monument Creek Provides Cooling Water (~40F)

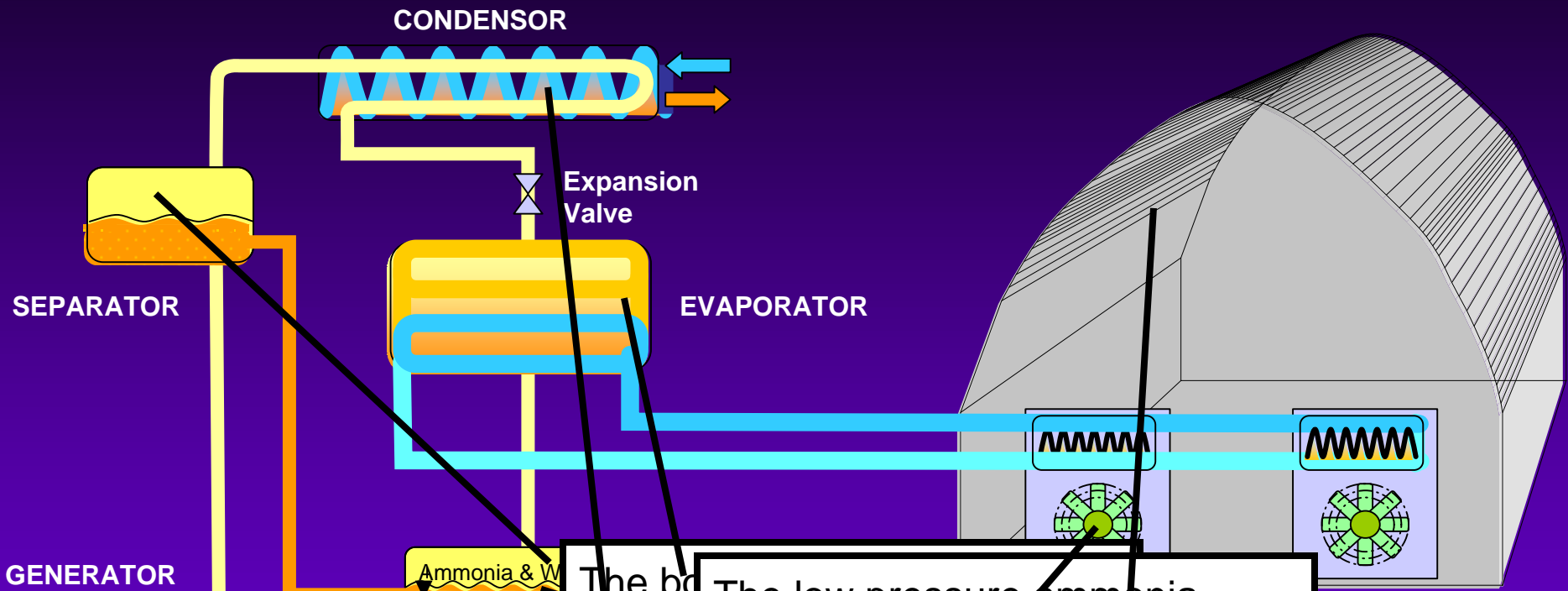


Geothermal Wells Provide Hot Water (~165F)



Approximately 15 tons of Refrigeration Required for Ice Museum (180 BTU per hour)

# CHENA HOT SPRINGS ABSORPTION CHILLER



The boiler is heated by a Calcium Chloride (CaCl<sub>2</sub>) brine solution. The low pressure ammonia vapor enters the Absorber where it is absorbed by water. The solution then moves to the Separator. The ammonia vapor is separated and returns to the evaporator to start the process again.

Thermocouples measure the temperature inside the ducts and the main Ice Museum Gallery, and these temperatures are continually monitored back at the Absorption Refrigeration System.



# CHENA HOT SPRINGS ABSORPTION CHILLER



# CHENA HOT SPRINGS ABSORPTION CHILLER



## ABSORPTION CHILLER

<b>Cold Water Pump</b>	10hp
<b>Hot Water Pump</b>	10hp
<b>System Pumps</b>	2-1/2hp
<b>CaCl<sub>2</sub> Pump</b>	1-1/2hp
<b>Air Handler</b>	20hp
<b>TOTAL</b>	<b>44hp</b>

## BACKUP UNIT

<b>Operation</b>	107hp
<b>Circulating pump</b>	10hp
<b>CaCl<sub>2</sub> Pump</b>	1-1/2hp
<b>Air Handler</b>	20hp
<b>TOTAL</b>	<b>148hp</b>

# THE BOTTOM LINE



## ABSORPTION CHILLER

<b>kWhr Used</b>	50kW
<b>Fuel Cost</b>	\$180.00
<b>Operational Cost</b>	<b>\$300.00</b>

## BACKUP UNIT

<b>kWhr Used</b>	150kW
<b>Fuel Cost</b>	\$540.00
<b>Operational Cost</b>	<b>\$900.00</b>

Operating cost per day

# SYSTEM CHALLENGES



**Challenges associated with the defrost system for the air handlers**



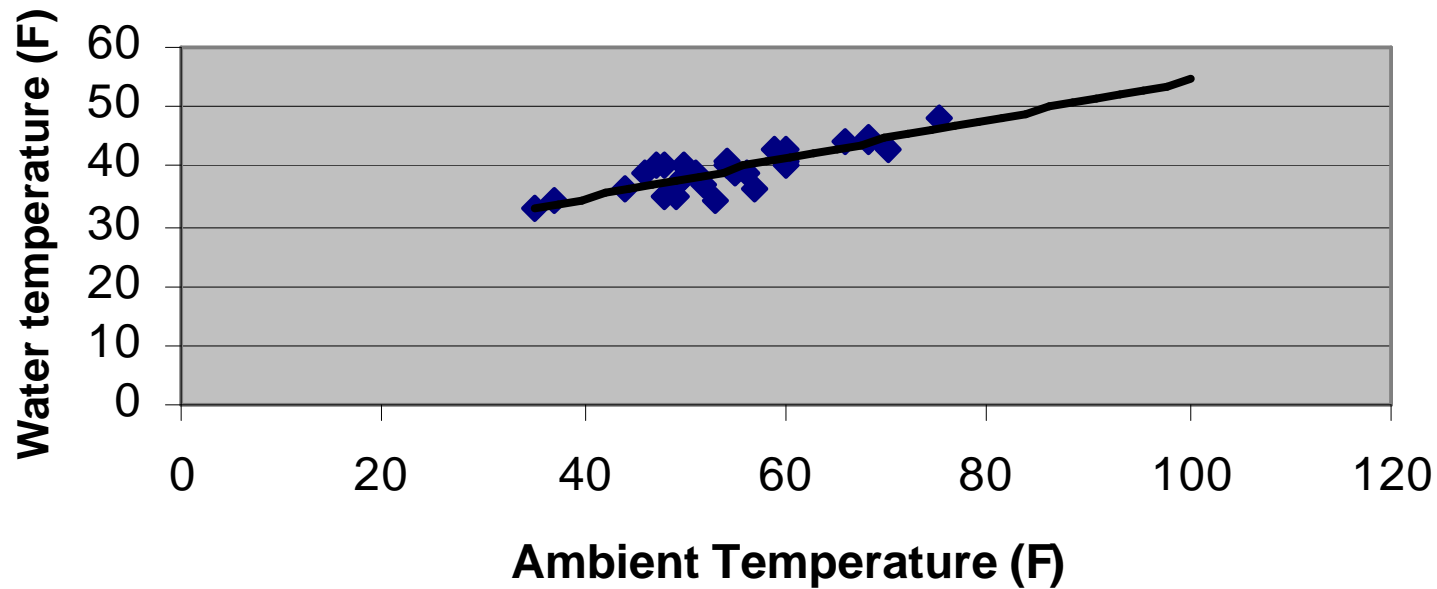


# SYSTEM CHALLENGES



## Inconsistent cooling water temperatures

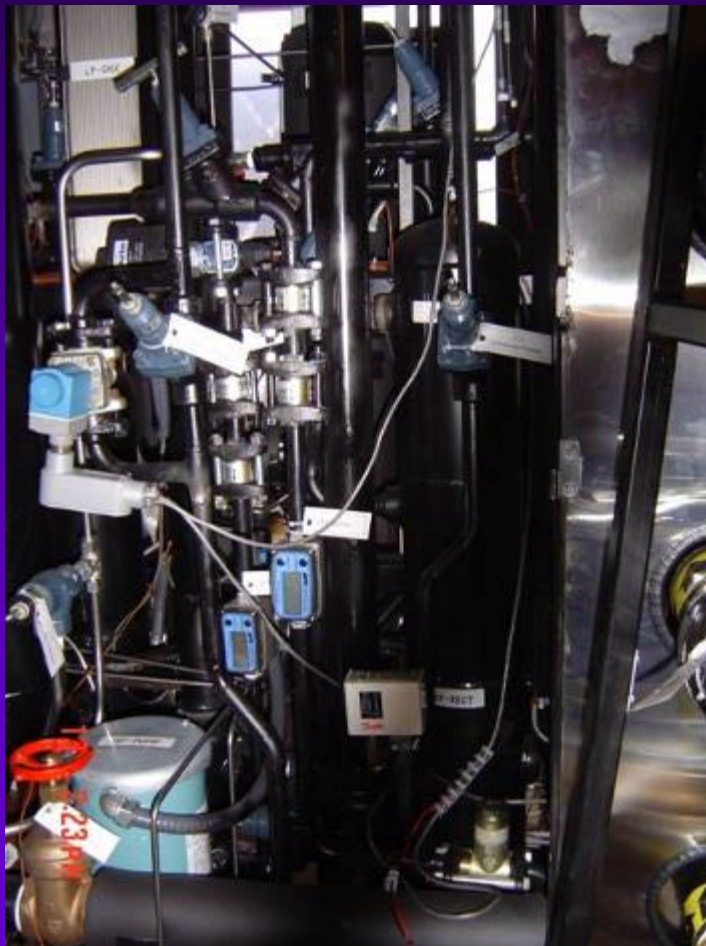
**Monument Creek Water Temperatures**  
as a function of ambient temperature



# SYSTEM CHALLENGES



## Challenges of Working With a Prototype Unit



# CONCLUSIONS



**Is Absorption Chilling viable for low temperature geothermal or other low grade waste heat applications?**

FROM THE GEOTHERMAL ENGINEERING HANDBOOK PUBLISHED BY THE O.I.T GEO-HEAT CENTER:  
**YES**  
'Substantial derating factors must be applied to equipment at temperatures less than 220F. Very high source temperatures of two-stage systems are required for low temperature refrigeration.'



# CHENA HOT SPRINGS RESORT

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