From Hot Water to Hydrogen

Bringing Geothermal Power to Alaska

CHENA HOT SPRINGS RESORT Alaska

Chena Hot Springs

- Discovered in 1905
- Purchased by the Karls in 1998
- 13,000+ overnight guests in 2005
- 60,000 additional day visitors
- Largest wintertime destination in Fairbanks North Star borough

Chena Hot Springs

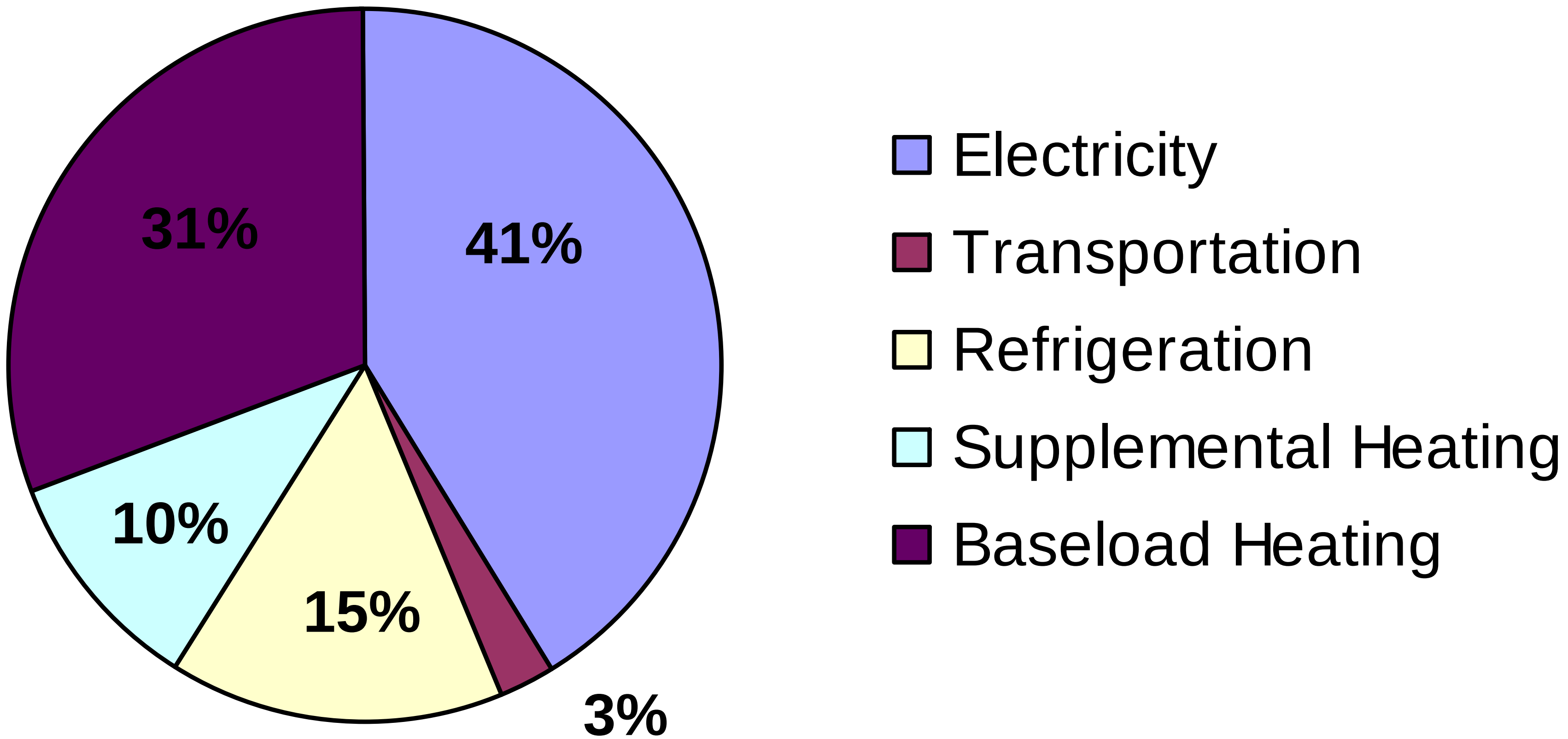
- Semi remote site
- Electric Power 30¢/kWhr
- Load 180kW-280kW

- $1000/day in diesel fuel at $2.50 per gallon
- $365,000 per year in fuel costs at today's price

Chena Hot Springs VISION:

To become a self-sustaining community in terms of energy, food, heating and fuel to the greatest possible extent

Energy Needs at Chena Hot Springs



AURORA ICE MUSEUM

1st Aurora Ice ‘Hotel’ completed in January, 2004 …

AURORA ICE MUSEUM

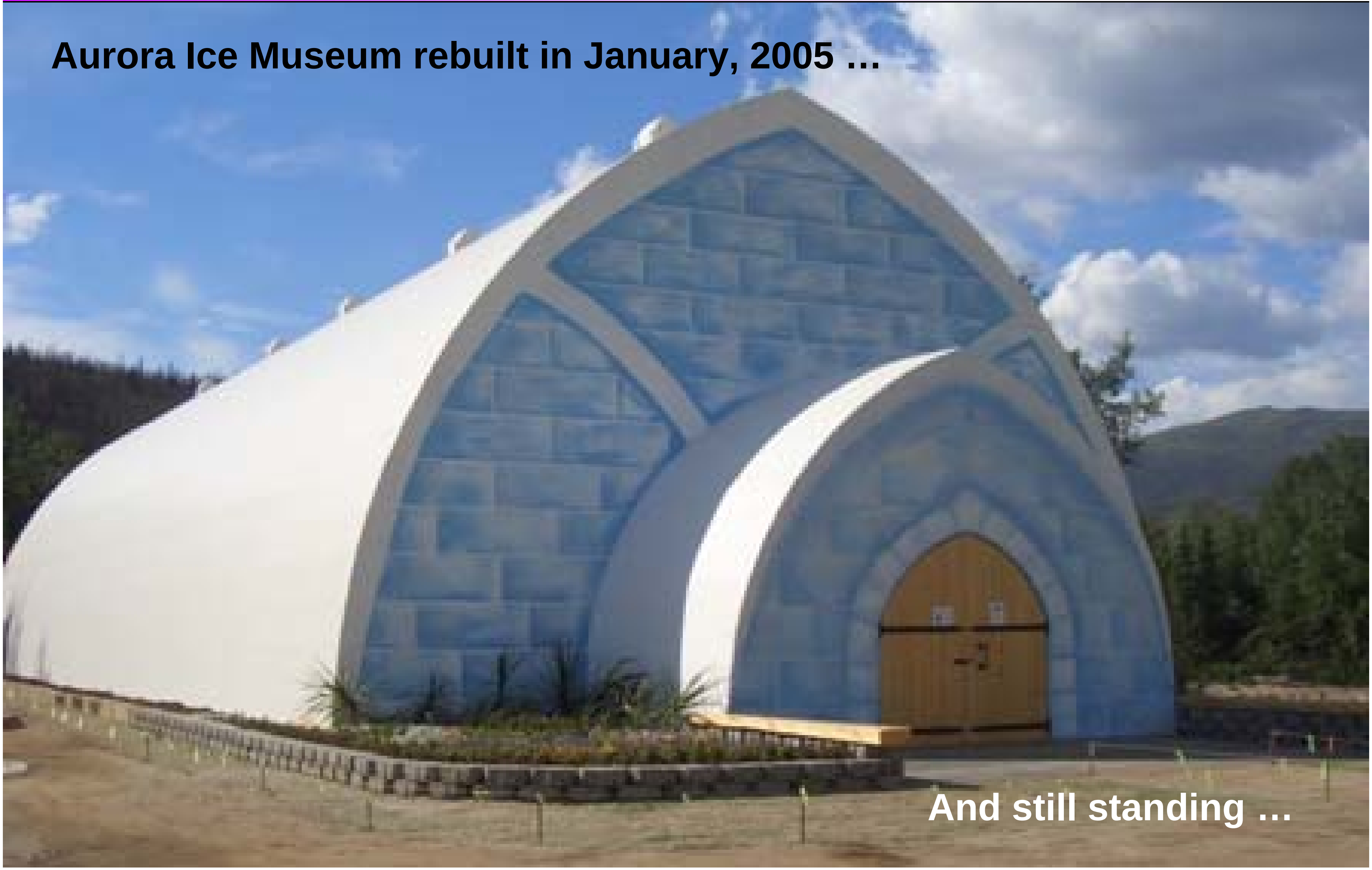
Voted as number 'best business idea' of 2004 by Forbes Magazine

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

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

AURORA ICE MUSEUM

Aurora Ice Museum rebuilt in January, 2005 …



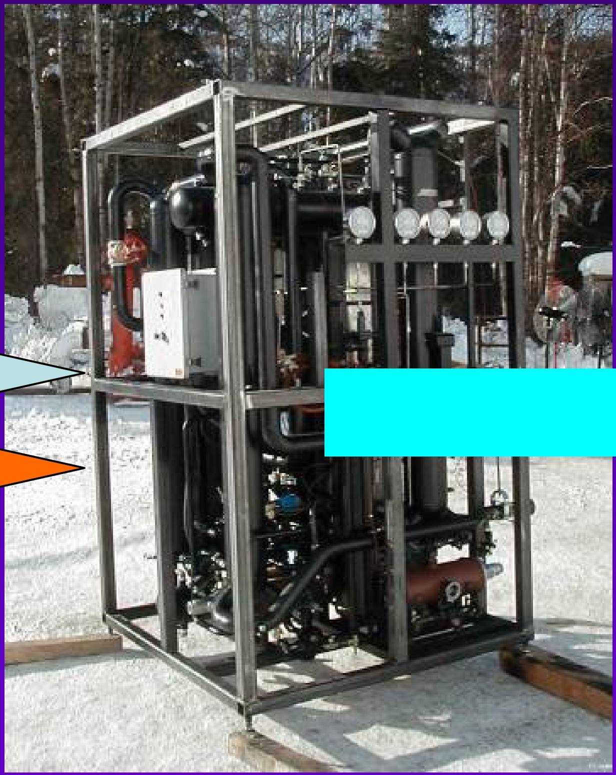
And still standing …


AURORA ICE MUSEUM

CHENA HOT SPRINGS ABSORPTION CHILLER

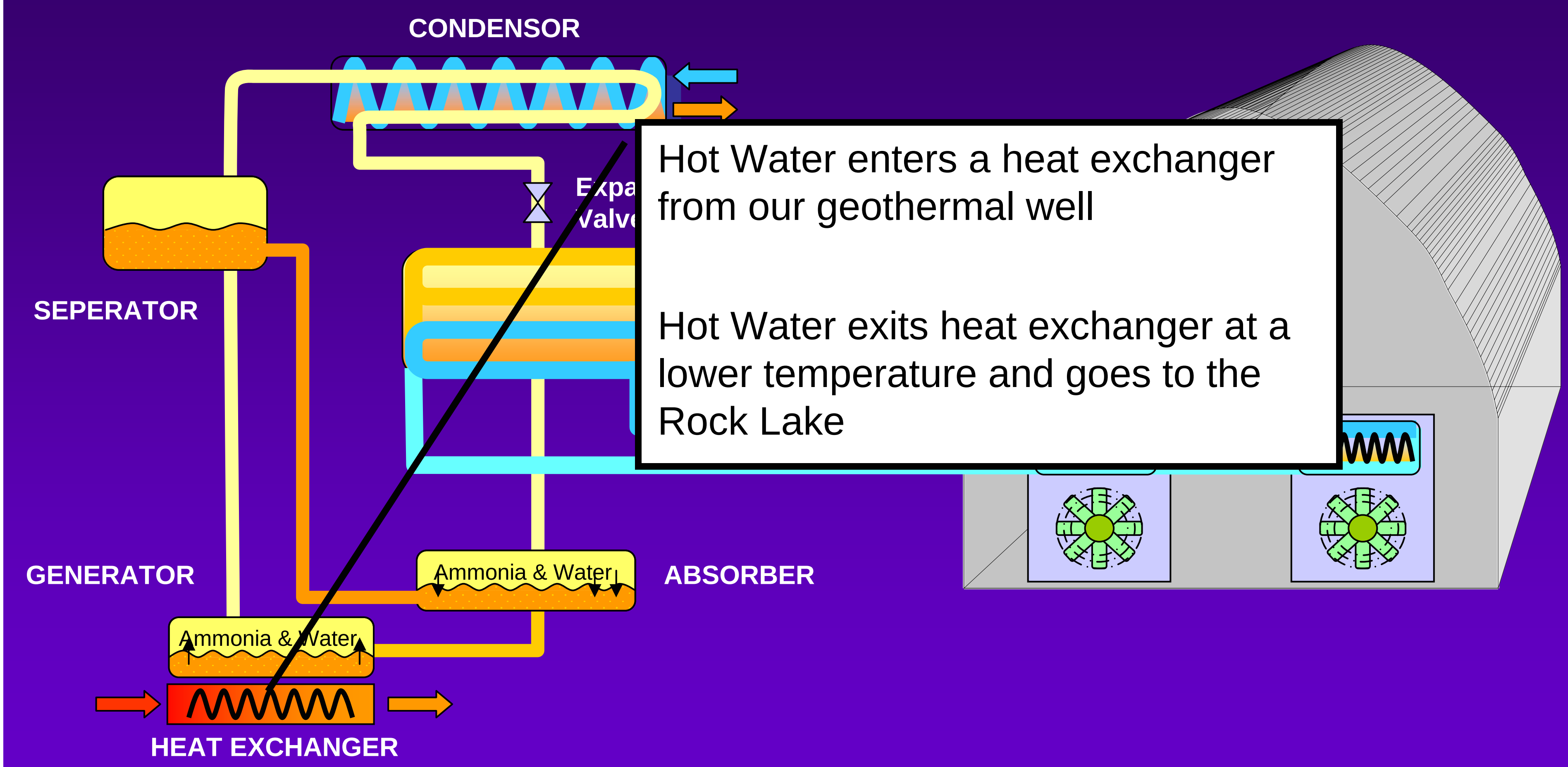
Monument Creek Provides Cooling Water (~40F)

Geothermal Wells Provide Hot Water (~165F)



Approximately 15 tons of Refrigeration Required for Ice Museum (180,000 BTU per hour)

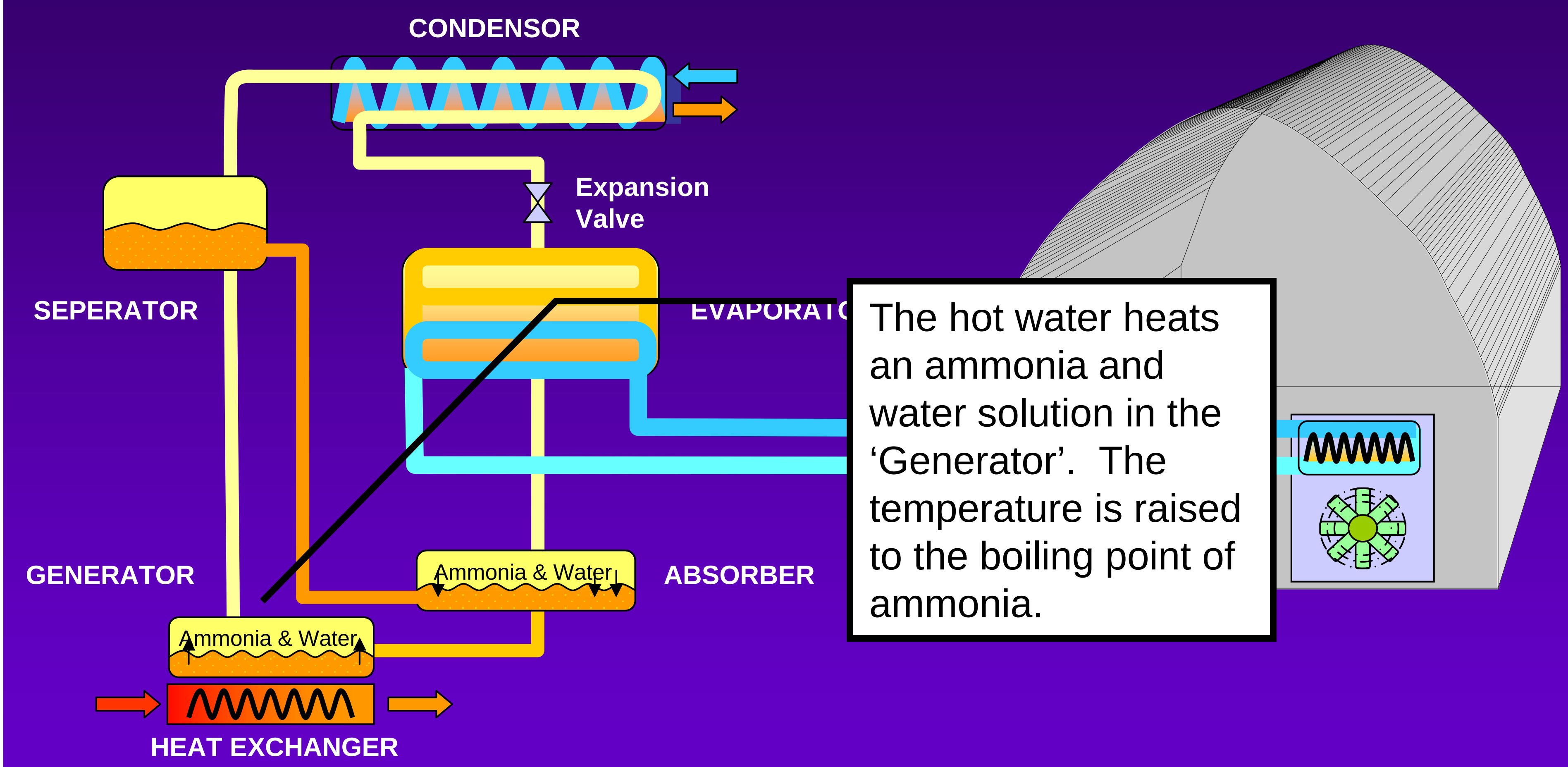
CHENA HOT SPRINGS ABSORPTION CHILLER



Hot Water enters a heat exchanger from our geothermal well

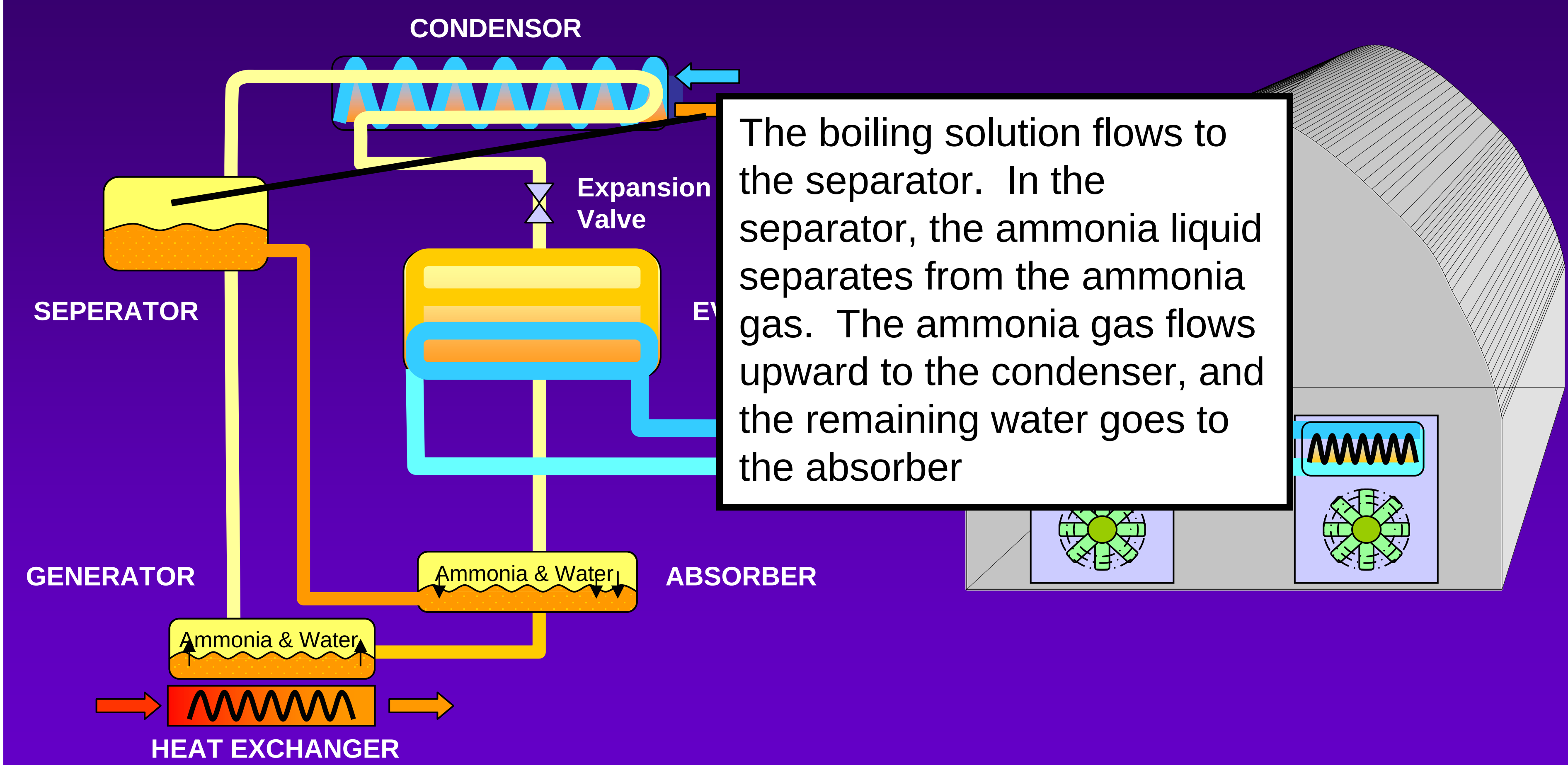
Hot Water exits heat exchanger at a lower temperature and goes to the Rock Lake

CHENA HOT SPRINGS ABSORPTION CHILLER



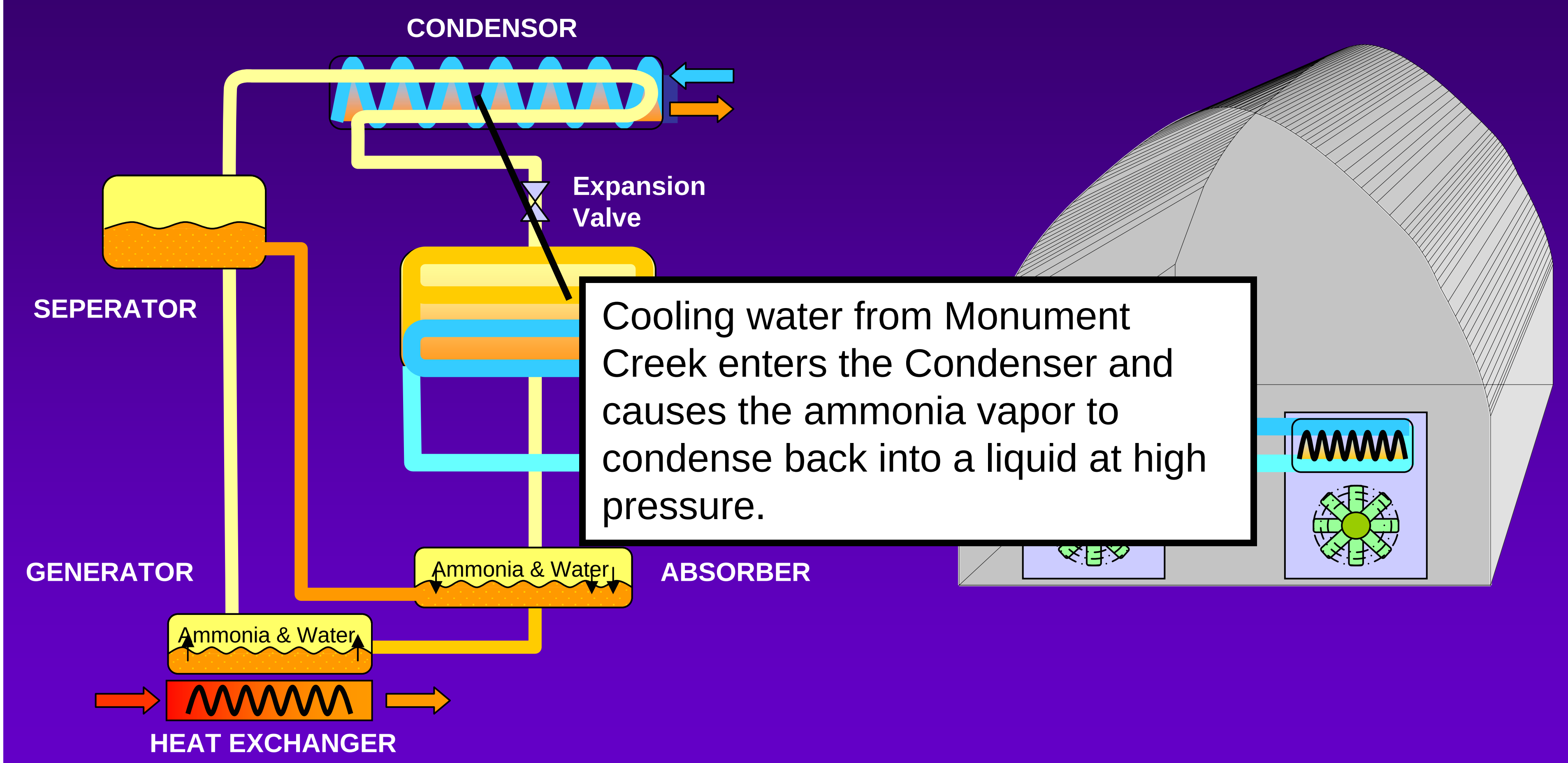
The hot water heats an ammonia and water solution in the ‘Generator’. The temperature is raised to the boiling point of ammonia.

CHENA HOT SPRINGS ABSORPTION CHILLER



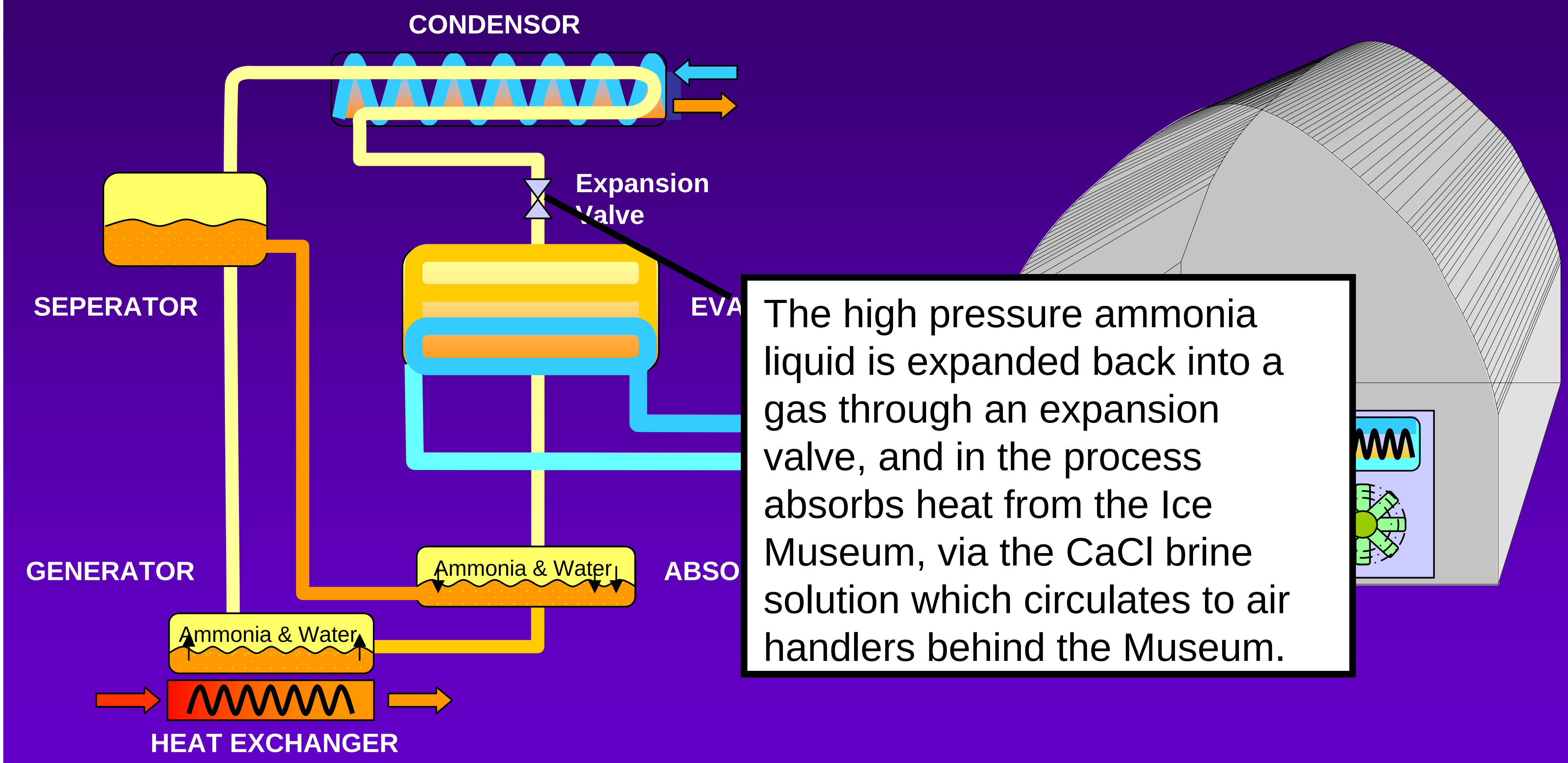
The boiling solution flows to the separator. In the separator, the ammonia liquid separates from the ammonia gas. The ammonia gas flows upward to the condenser, and the remaining water goes to the absorber

CHENA HOT SPRINGS ABSORPTION CHILLER



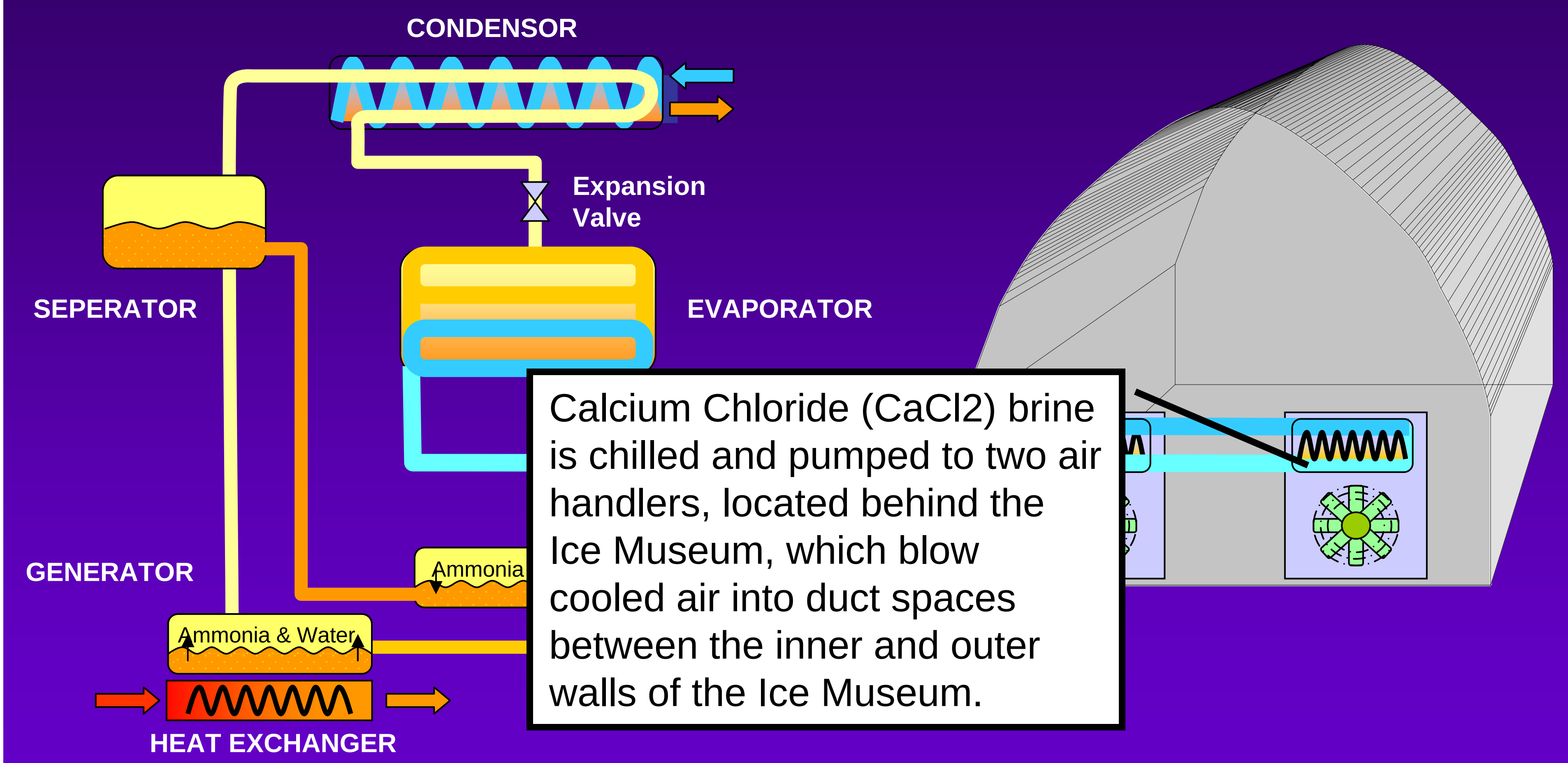
Cooling water from Monument Creek enters the Condenser and causes the ammonia vapor to condense back into a liquid at high pressure.

CHENA HOT SPRINGS ABSORPTION CHILLER



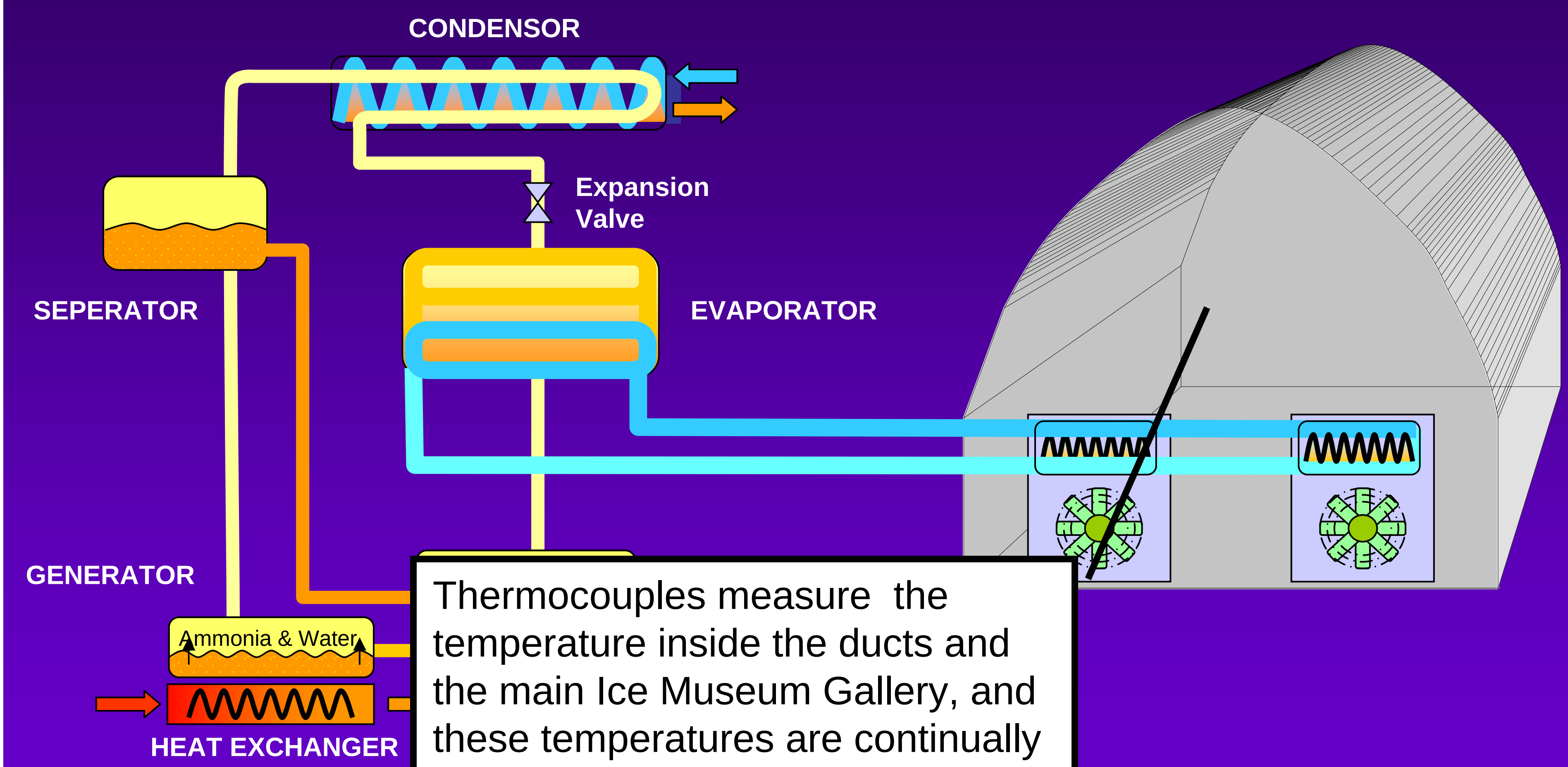
The high pressure ammonia liquid is expanded back into a gas through an expansion valve, and in the process absorbs heat from the Ice Museum, via the CaCl brine solution which circulates to air handlers behind the Museum.

CHENA HOT SPRINGS ABSORPTION CHILLER



Calcium Chloride (CaCl2) brine is chilled and pumped to two air handlers, located behind the Ice Museum, which blow cooled air into duct spaces between the inner and outer walls of the Ice Museum.

CHENA HOT SPRINGS ABSORPTION CHILLER

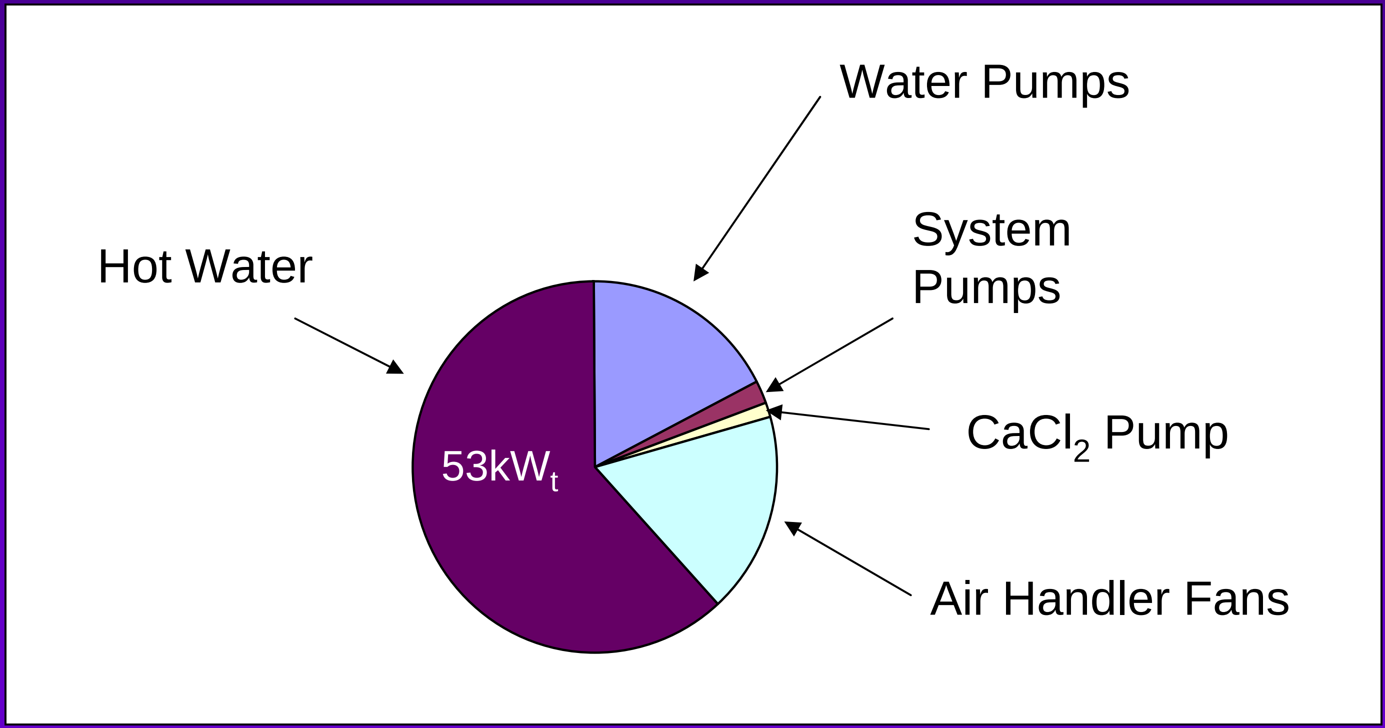


Thermocouples measure the temperature inside the ducts and the main Ice Museum Gallery, and these temperatures are continually monitored back at the Absorption Refrigeration System.

CHENA HOT SPRINGS ABSORPTION CHILLER

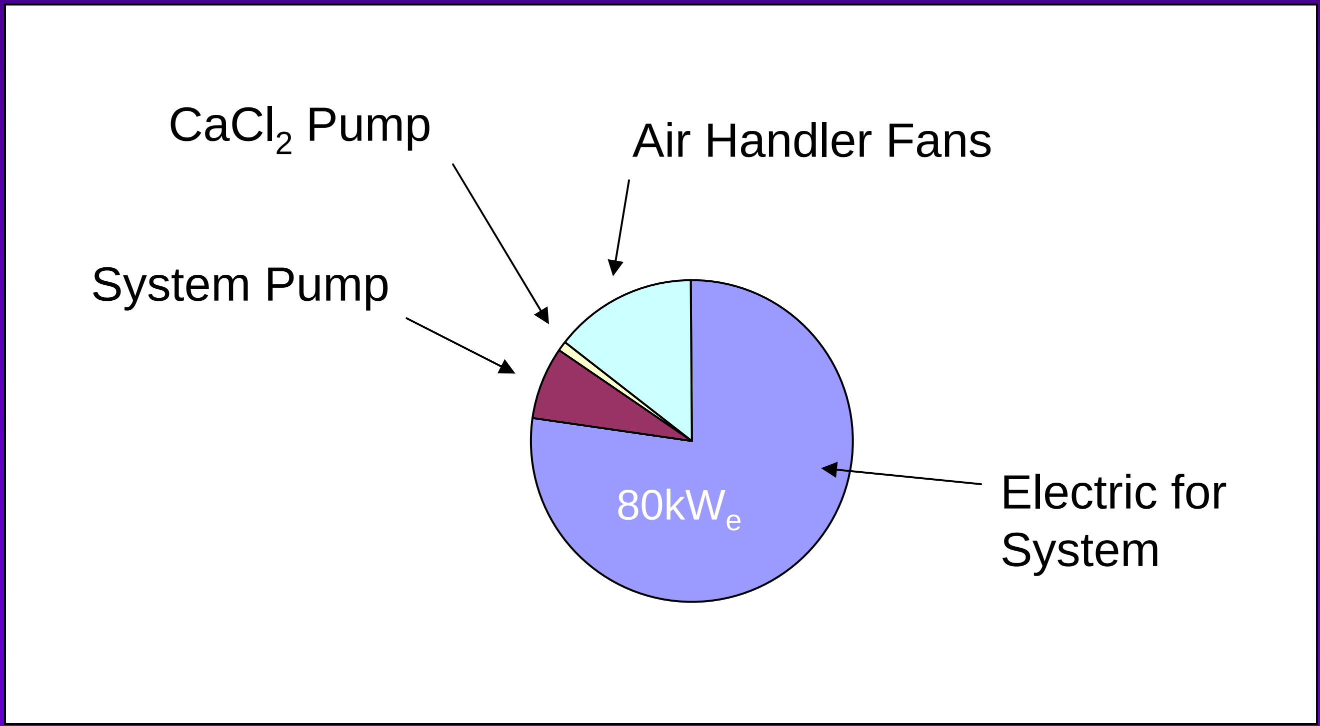
TOTAL COOLING SYSTEM POWER USE = 33kW_e

IF WE DISCOUNT WELL PUMP = 25kW_e

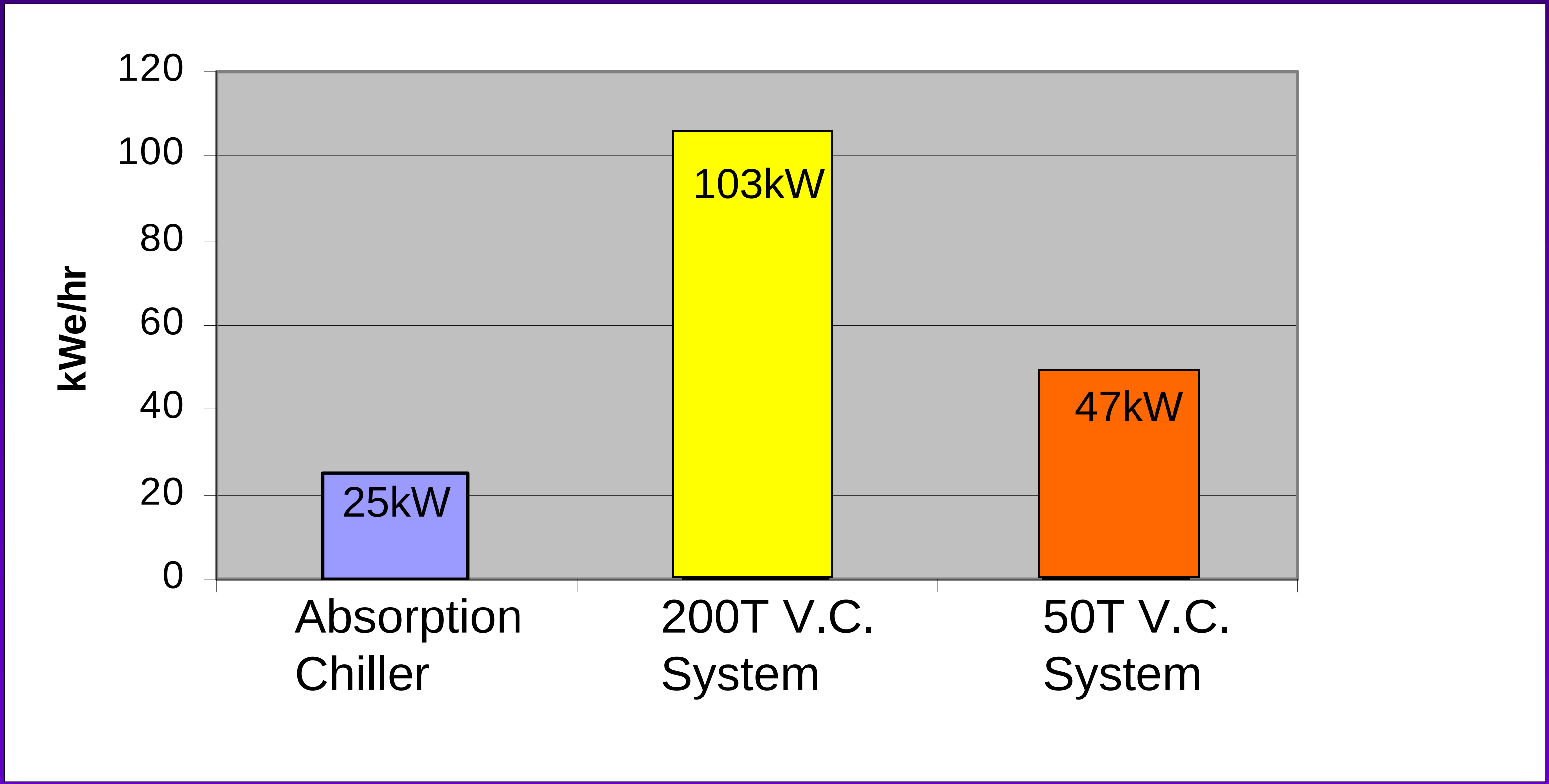


BACKUP VAPOR COMPRESSION SYSTEM

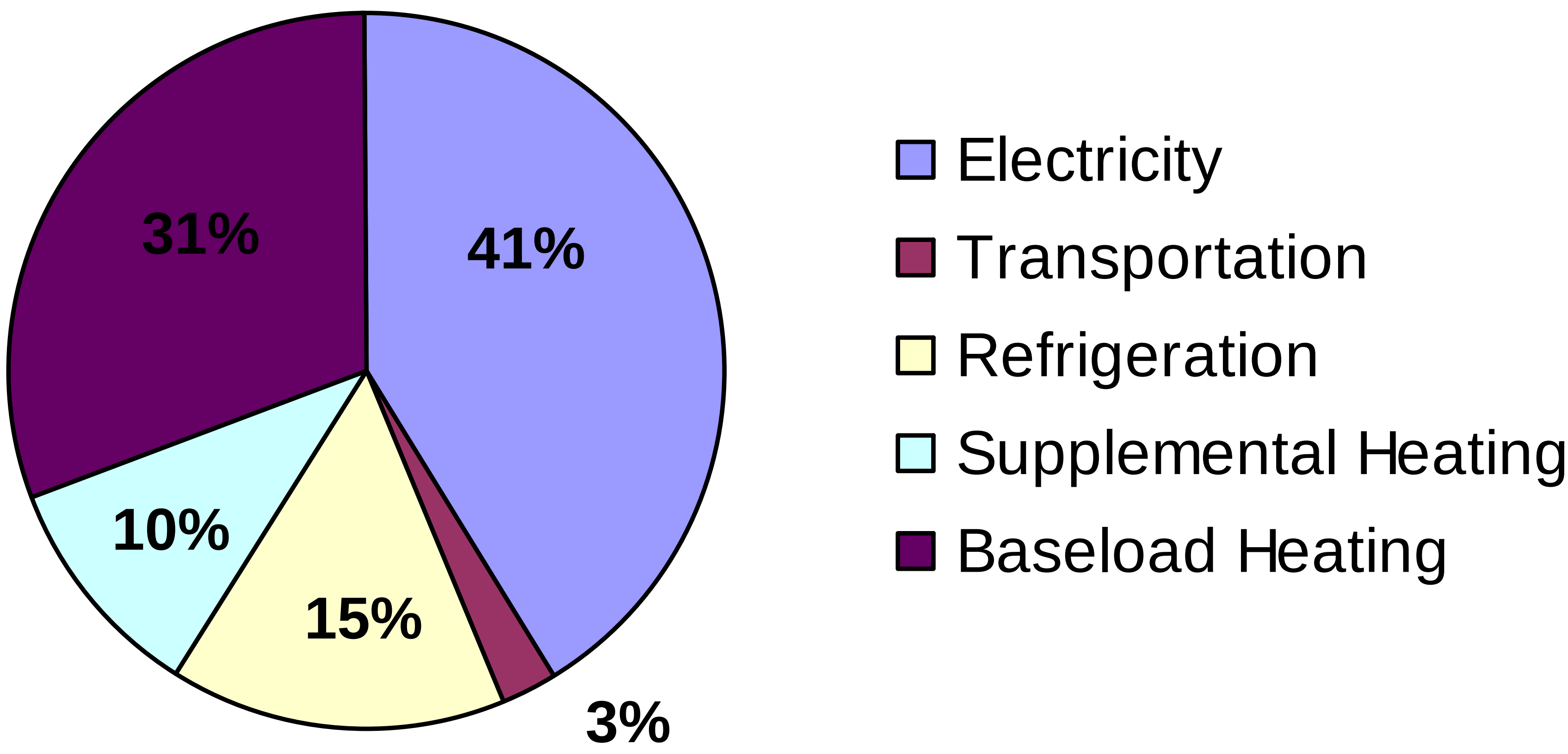
TOTAL V.C. SYSTEM POWER USE = 103kW_e



CHENA HOT SPRINGS ABSORPTION CHILLER



Energy Needs at Chena Hot Springs



District Heating

- First geothermal well drilled in March 1998

District Heating

- First geothermal well drilled in March 1998
- All buildings on property are heated geothermally using ~300gpm of 165°F water
- Estimated yearly savings of $183,000 in heating fuel coats

Moose Lodge, 20,000ft² heated solely with geothermal district heating system

Greenhouse & Gardens

- First greenhouse established in 2004 as a joint project between Chena Hot Springs and UAF
- Producing crops for onsite use on a year-round basis

Greenhouse & Gardens

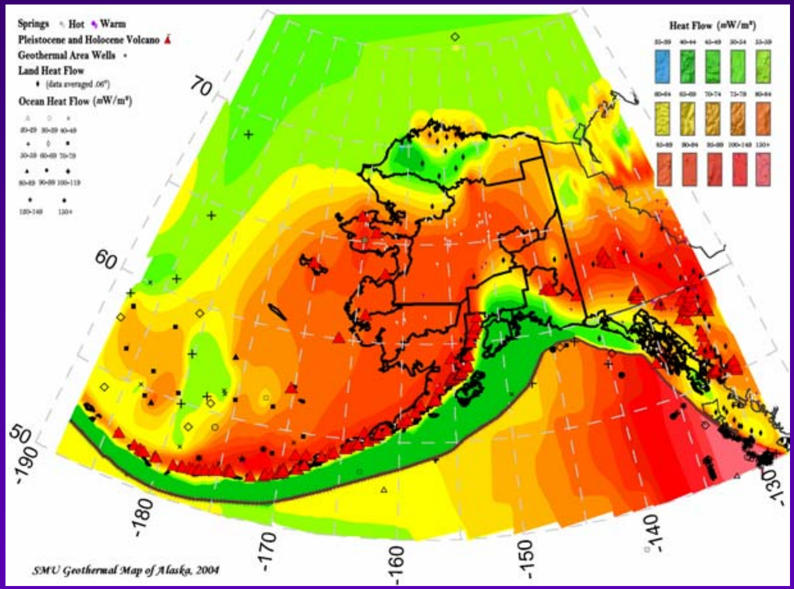
- First greenhouse established in 2004 as a joint project between Chena Hot Springs and UAF
- Producing crops for onsite use on a year-round basis
- New 5000ft greenhouse recently completed for 2006 season
- Heated from geothermal wells but could operate off any waste heat source

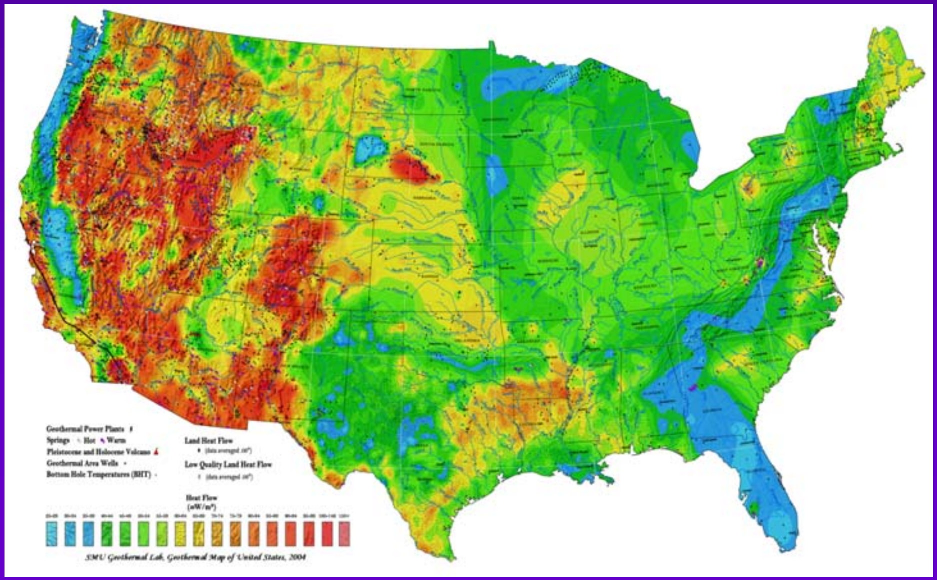
Greenhouse & Gardens

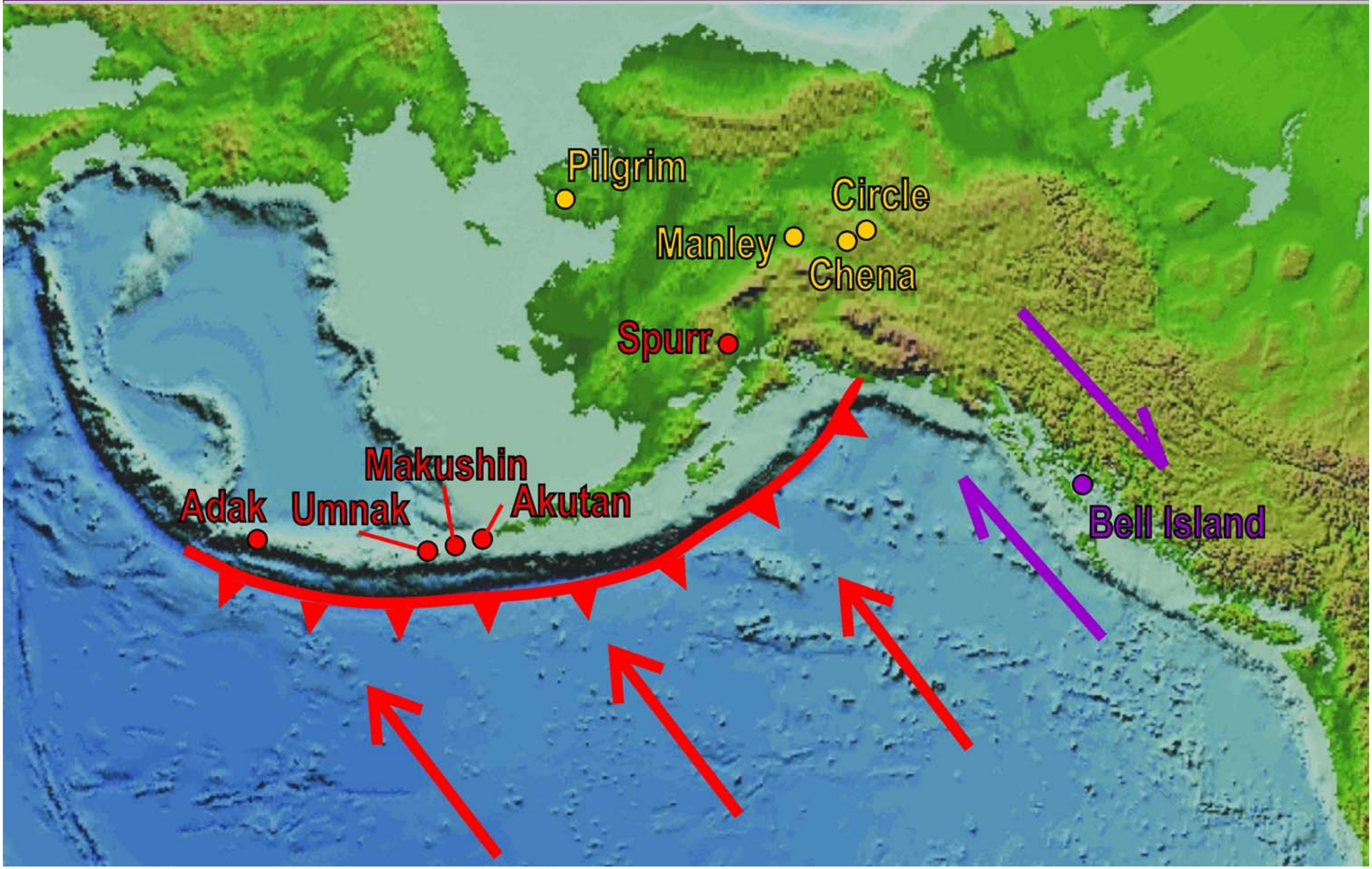
Geothermally Heated Greenhouse #2 at Chena Hot Springs Resort



Alaska's Geothermal Resources

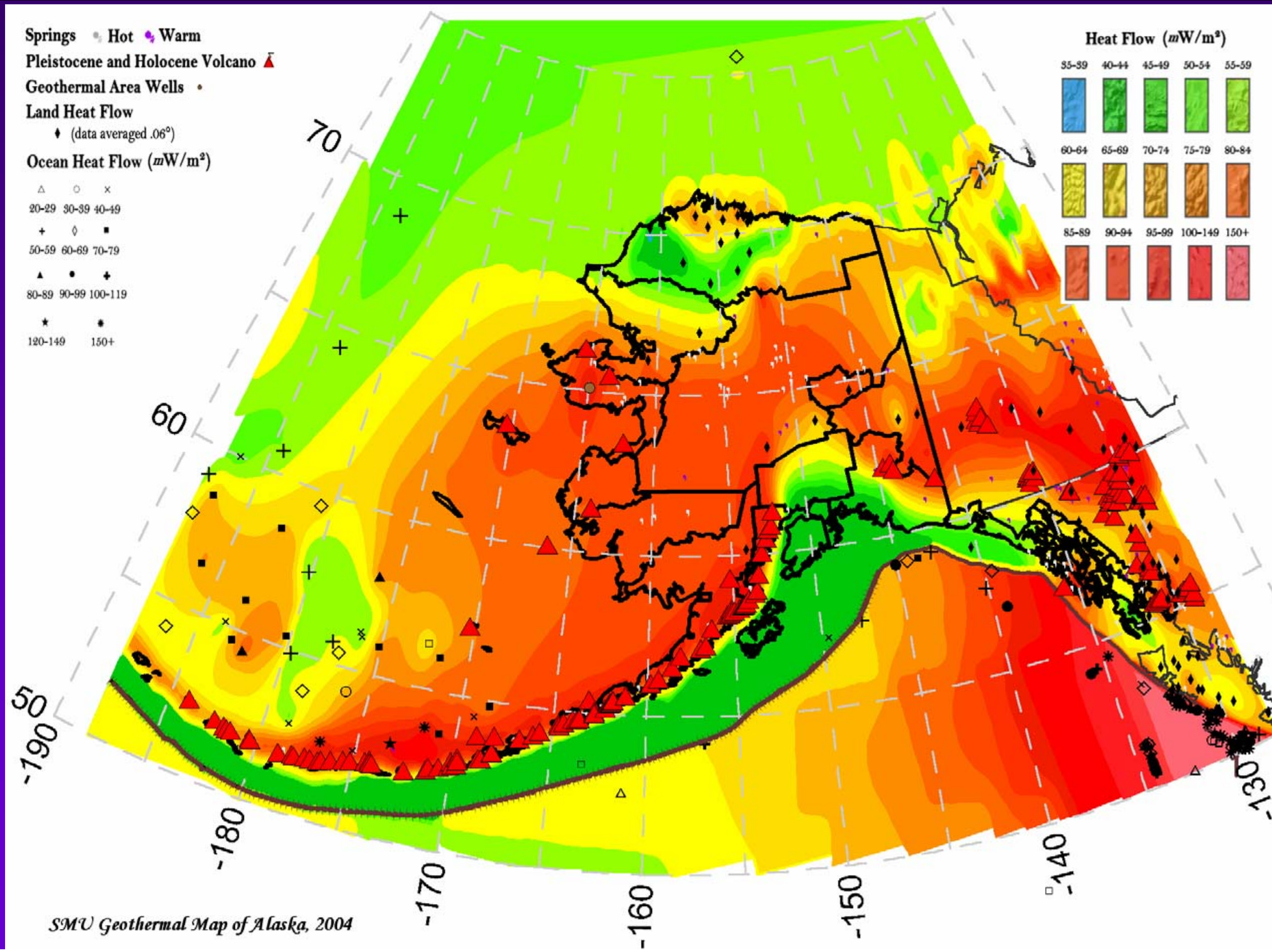






Pilgrim
Circle
Manley
Chena
Spurr
Makushin
Akutan
Adak
Umnak
Bell Island

Alaska's Geothermal Resources




Manley Hot Springs, Alaska T = 140F, T(res) = 210F

Circle Hot Springs, Alaska T = 140F T(res) = 284F

Melozi Hot Springs T = 131F RT = 240F

Kanuti Hot Springs T= 150F T(max) = 275F

Geyser Bight Fumarole Field (Umnak Island)

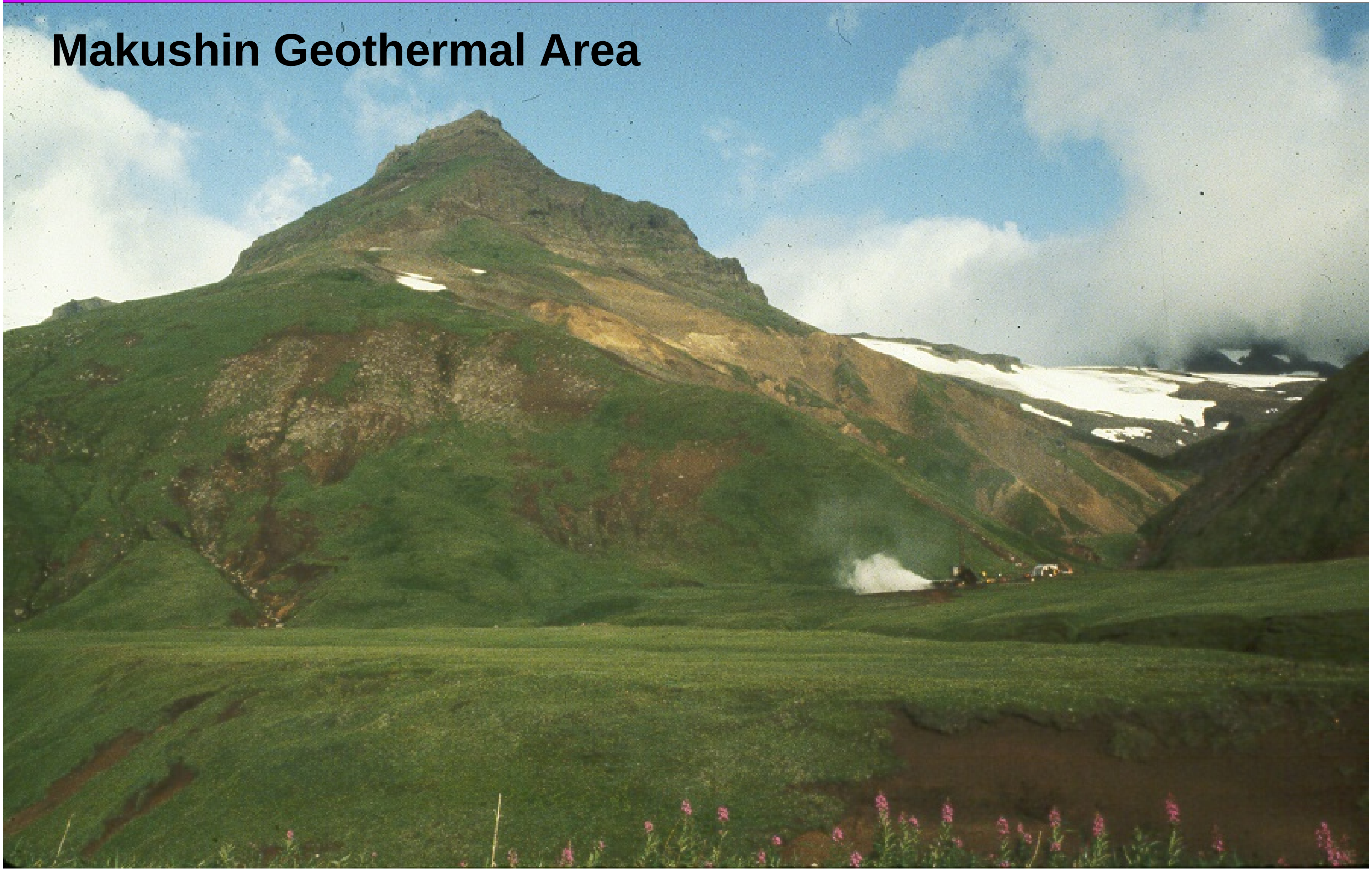
Geyser Bight – Geyser (Umnak Island)

Big Windy Creek Valley

Upper Division Hot Spring (Selawik National Wildlife Refuge – near Shungnak)

Makushin Geothermal Well - ready for testing

Makushin Geothermal Area



Drilling wells at Pilgrim Hot Springs 1979

View of Pilgrim HS Area - where the trees are

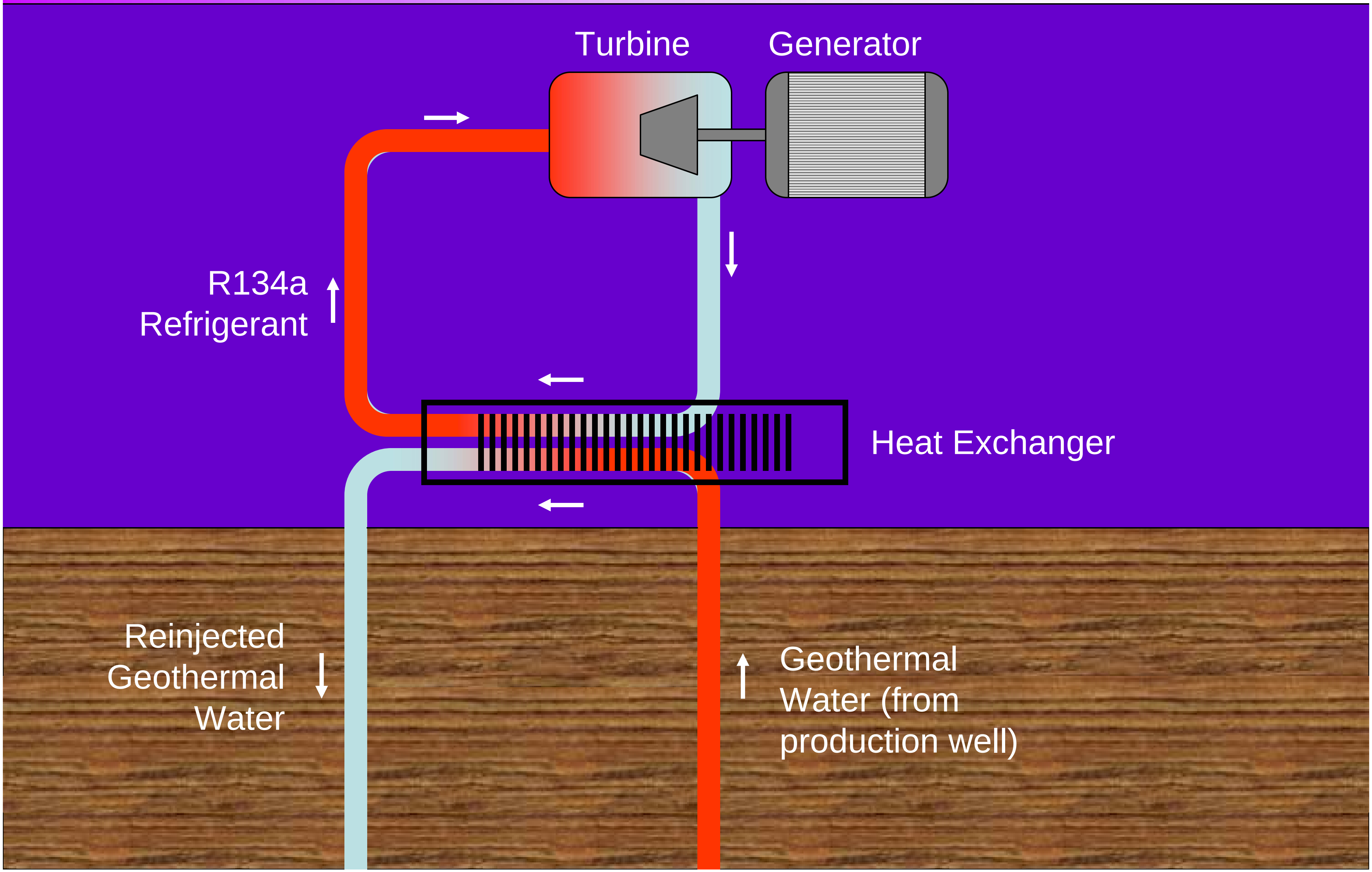
History

- First Geothermal Power produced in Lardarello, Italy in 1904
- First Power Plant in US at The Geysers in 1922
- First large scale power plant comes online at The Geysers in 1960
- First water dominated system developed for power in 1979 (Imperial Valley, CA)
- Ormat successfully demonstrates binary technology in the Imperial Valley of California.

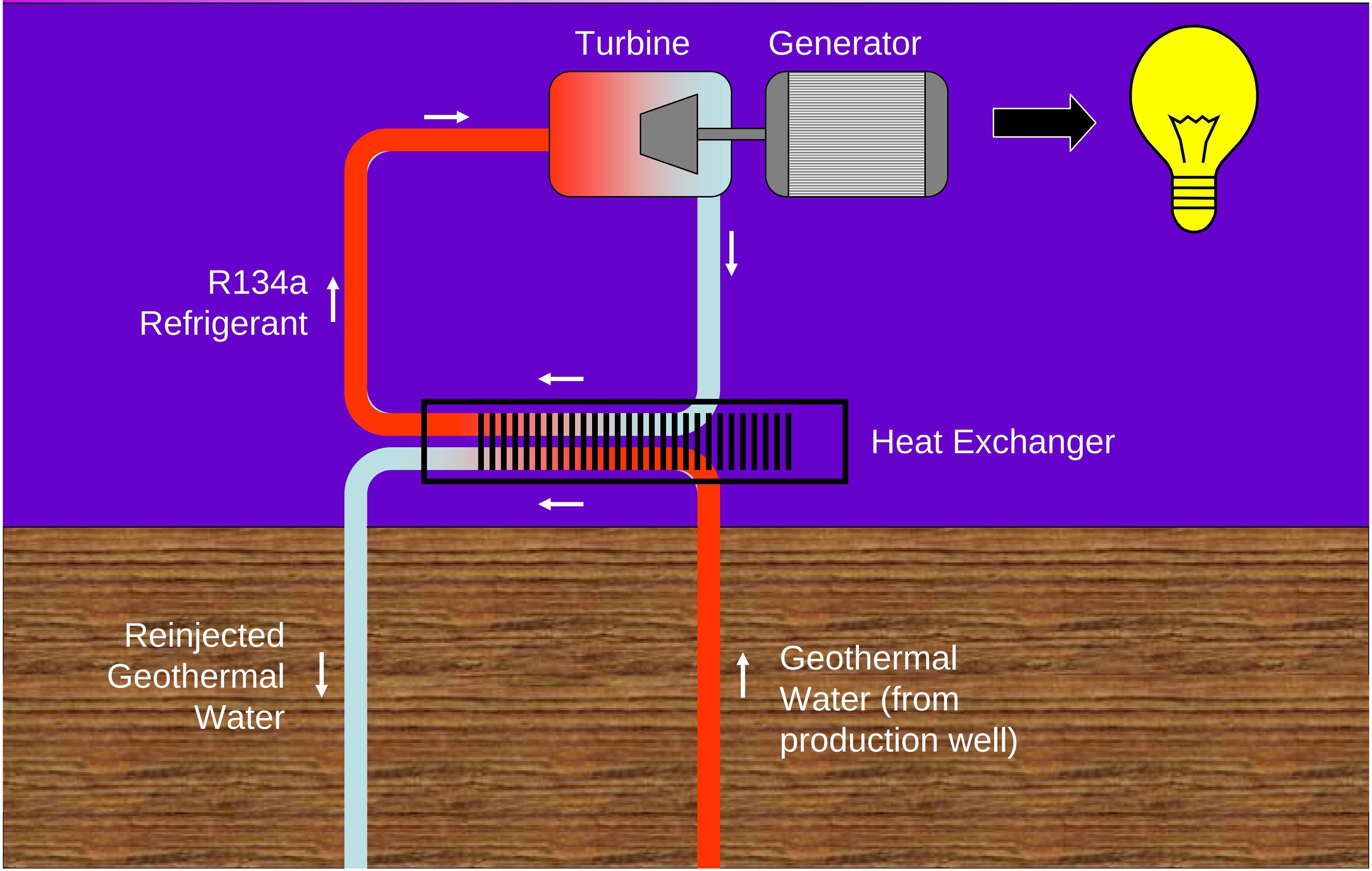
Lardarello, Italy – First Geothermal Power

The Geysers – First Large Geothermal Plant installed in 1960

Binary Cycle Power Plant



Binary Cycle Power Plant



History of ORC

Hawaii – 30MW installed in 2004

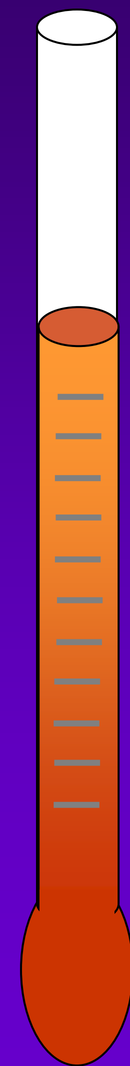
China – 1MW, installed in 1993

Kenya – 13.6MW installed in 2000

Indonesia – 49MW installed in 2002

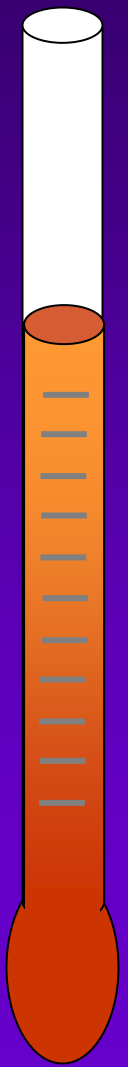
Conventional Wisdom for Absorption Chilling & Power Generation Cycles:

$T \geq 230^{\circ}F$



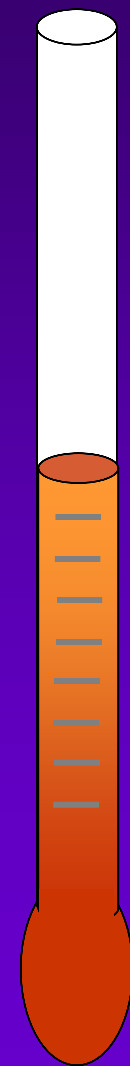
Conventional Wisdom for Absorption Chilling & Power Generation Cycles:

~~$T \geq 230^{\circ}F$~~



Conventional Wisdom for Absorption Chilling & Power Generation Cycles:

$$T \geq 165^{\circ}F$$

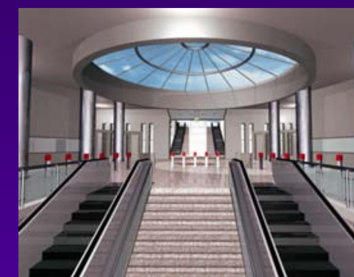


United Technologies

UTC Fire & Security
Security &
Fire Protection

Pratt & Whitney
Aircraft Engines,
Gas Turbines &
Space Propulsion

Carrier
Heating, Cooling
& Refrigeration



Otis
Elevators,
Escalators &
People Moving
Systems

UTC divisions span many markets and industries…

UTC Research Center
– Technology
Advancement

UTC Fuel Cells
On-site &
Transportation

Hamilton Sundstrand
Aerospace & Industrial

Sikorsky
Helicopters

United Technologies

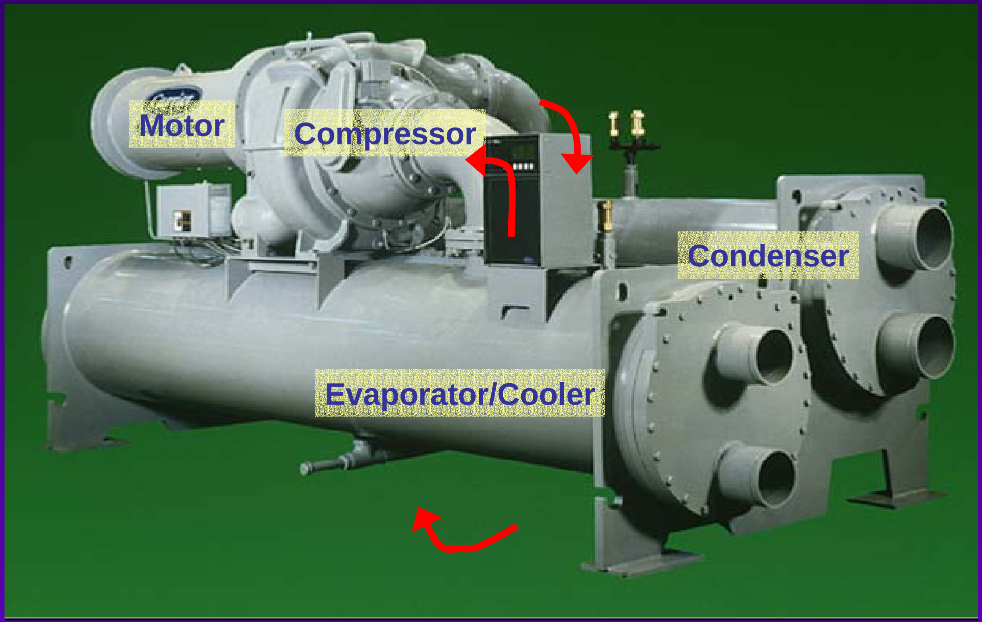
Carrier
Heating, Cooling & Refrigeration

Collaboration between divisions leads to the formation Of UTC Power and the development of their CHP product line

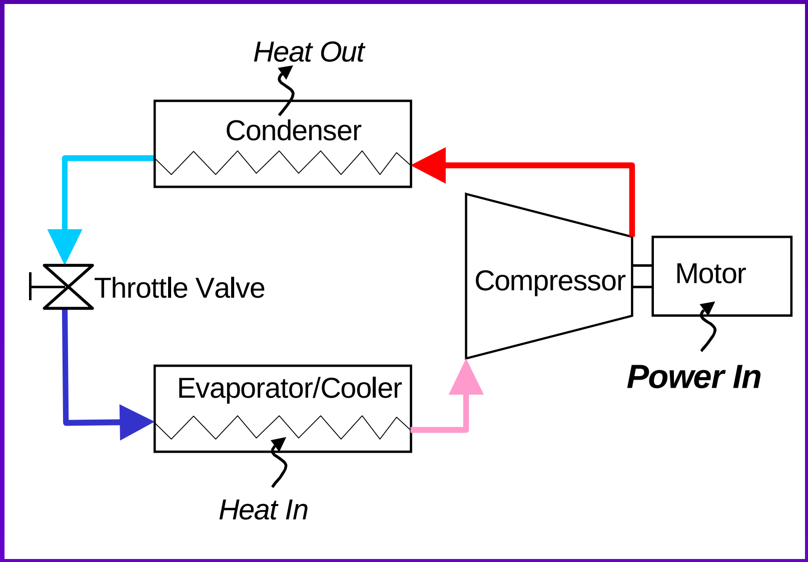
UTC Research Center
– Technology Advancement

UTC Fuel Cells
On-site & Transportation

Carrier Chiller

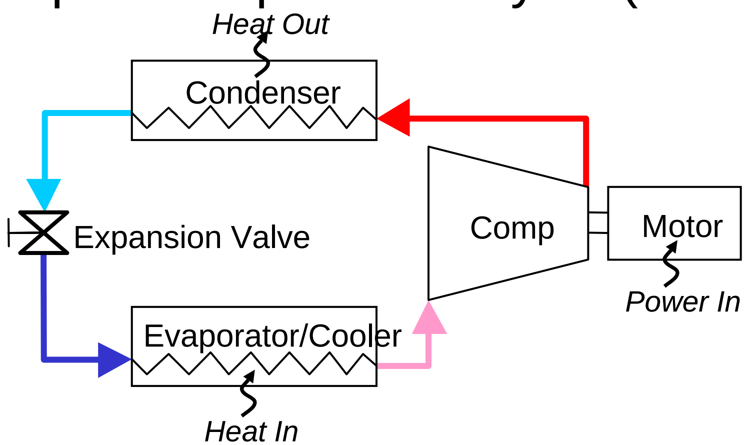


Refrigeration Cycle

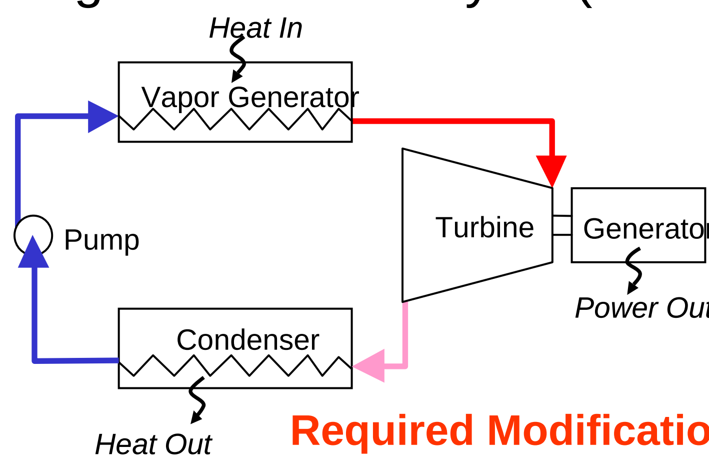


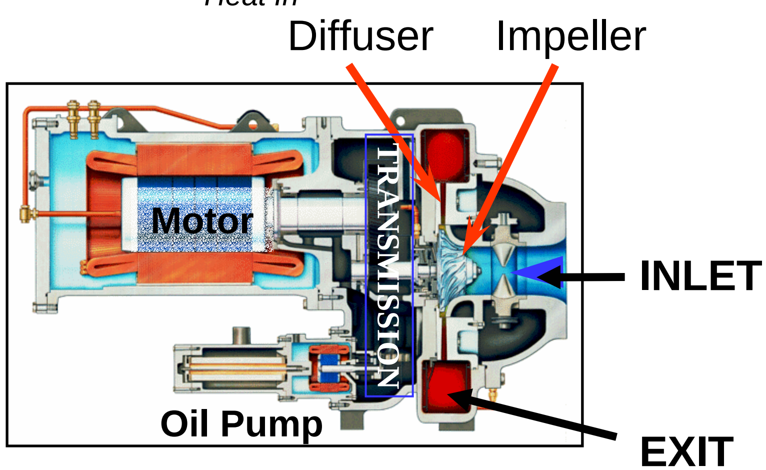
Carrier Turbine Generator

Vapor Compression Cycle (VCC)



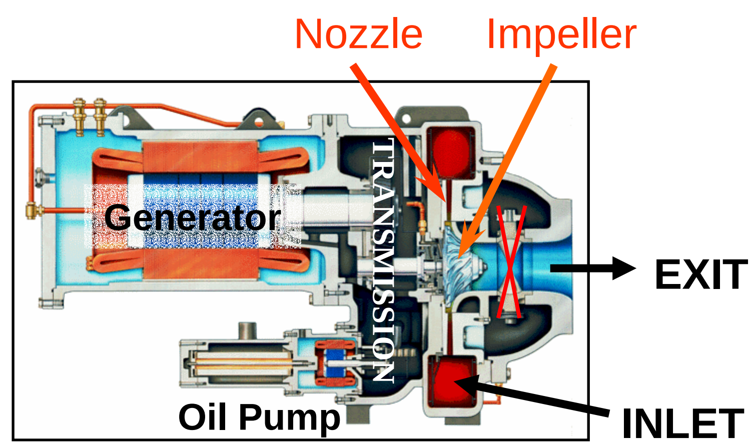
Organic Rankine Cycle (ORC)





19 XR225 Centrifugal Compressor

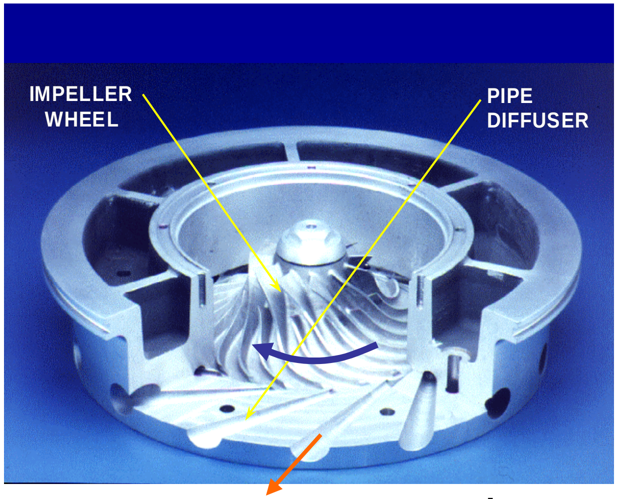
Required Modifications



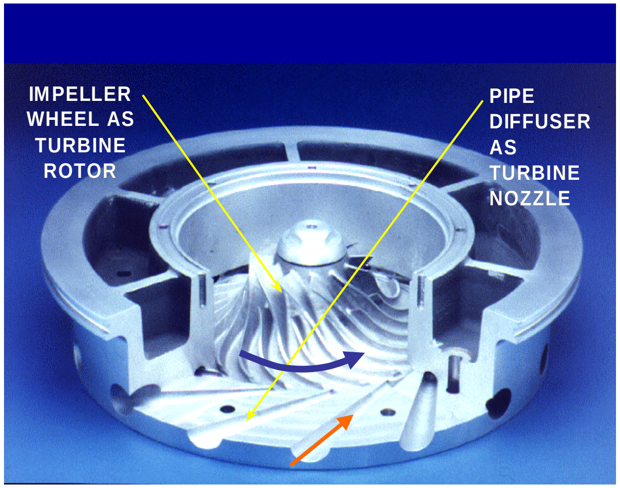
19 XR225 Radial Turbine

Carrier Turbine Generator

Adaptation of Existing Hardware - Compressor versus Turbine Operation



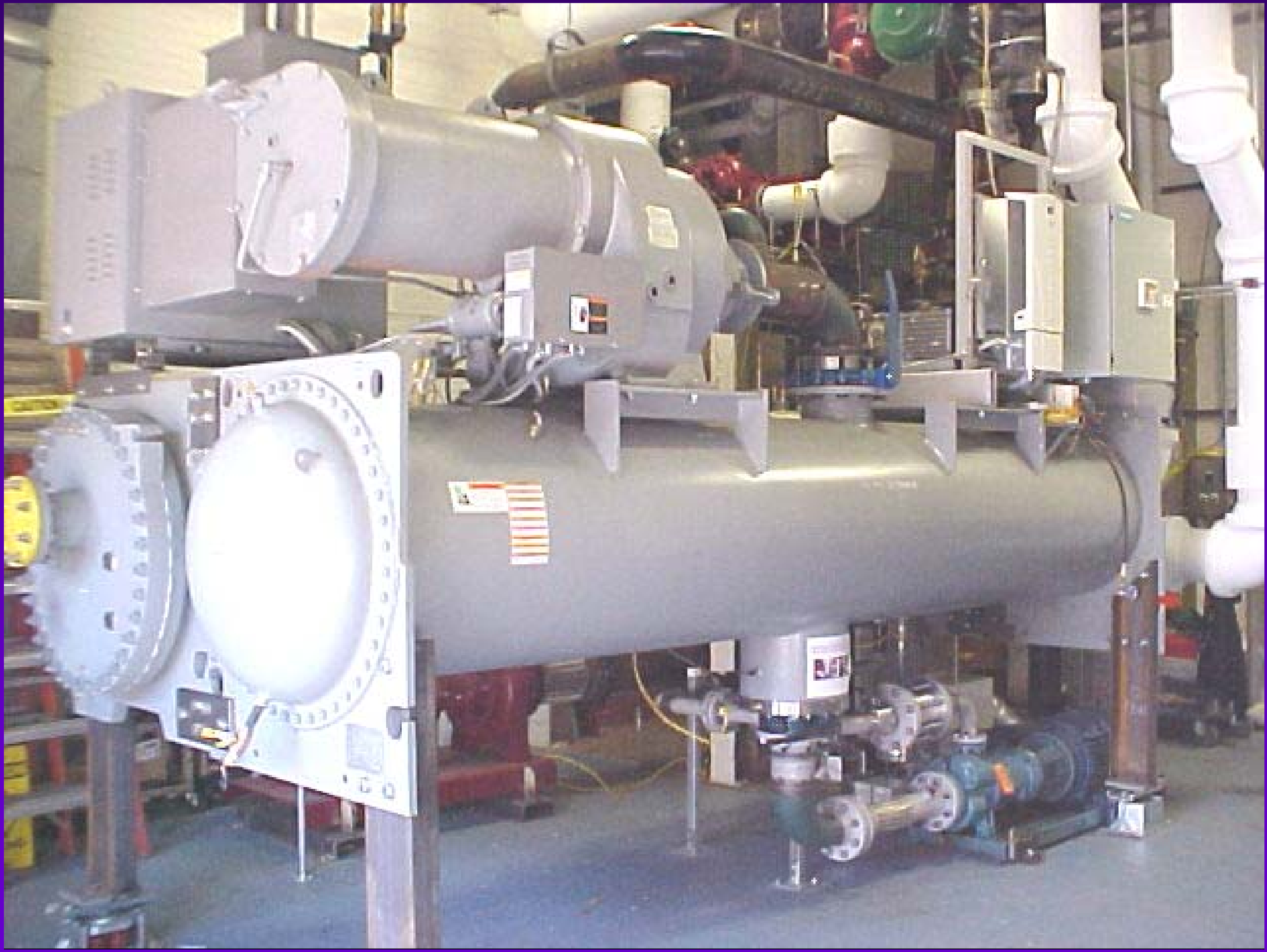
Compressor Operation:
Cut-away Of Impeller
(Spinning Clockwise)
and Pipe Diffuser
(Radial Outward Flow)



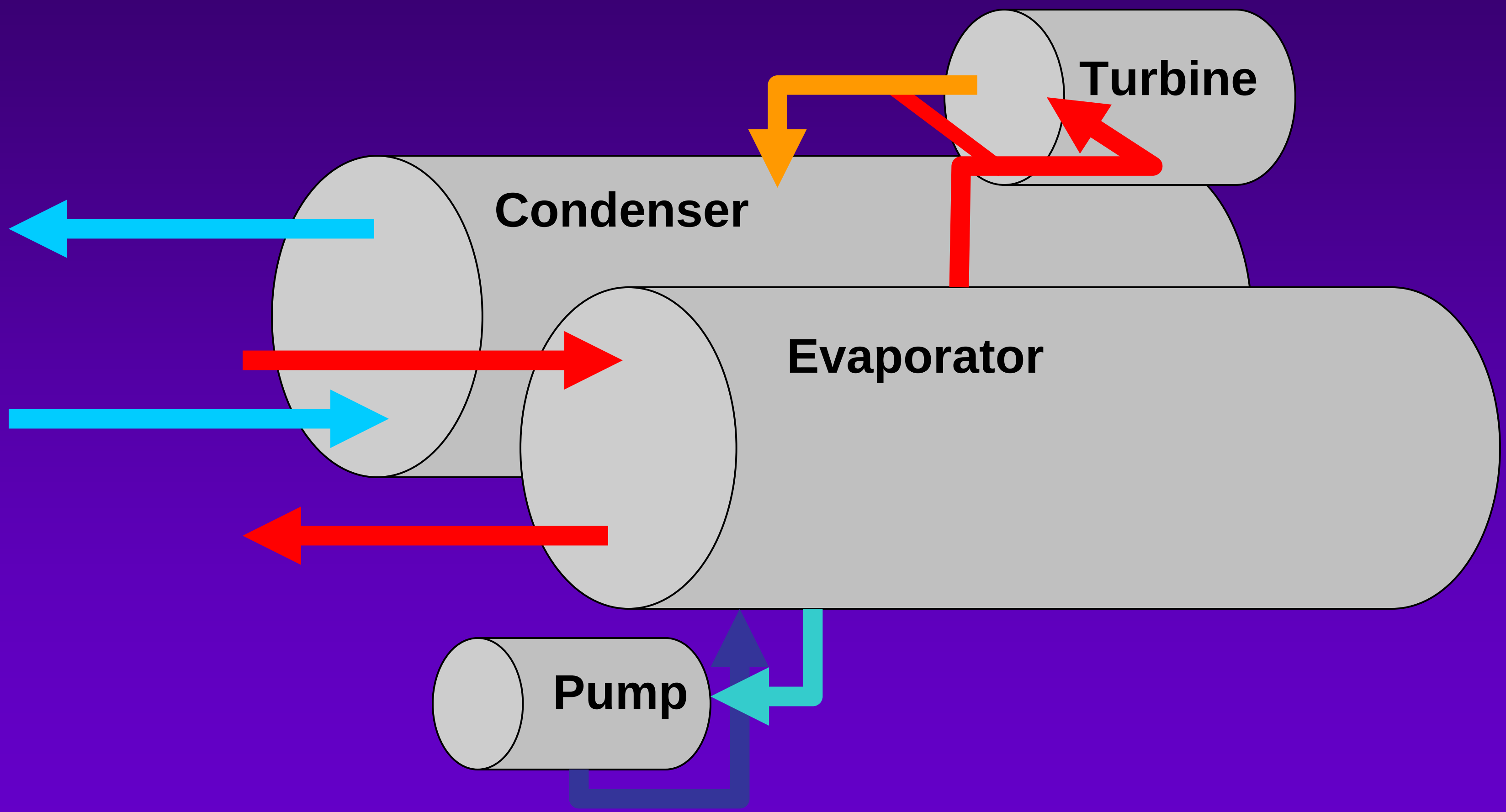
Turbine Operation:
Cut-away Of Impeller
(Spinning Counter-clockwise)
and Pipe Diffuser
(Radial Inward Flow)

Impeller, nozzle and shroud – only changes to compressor

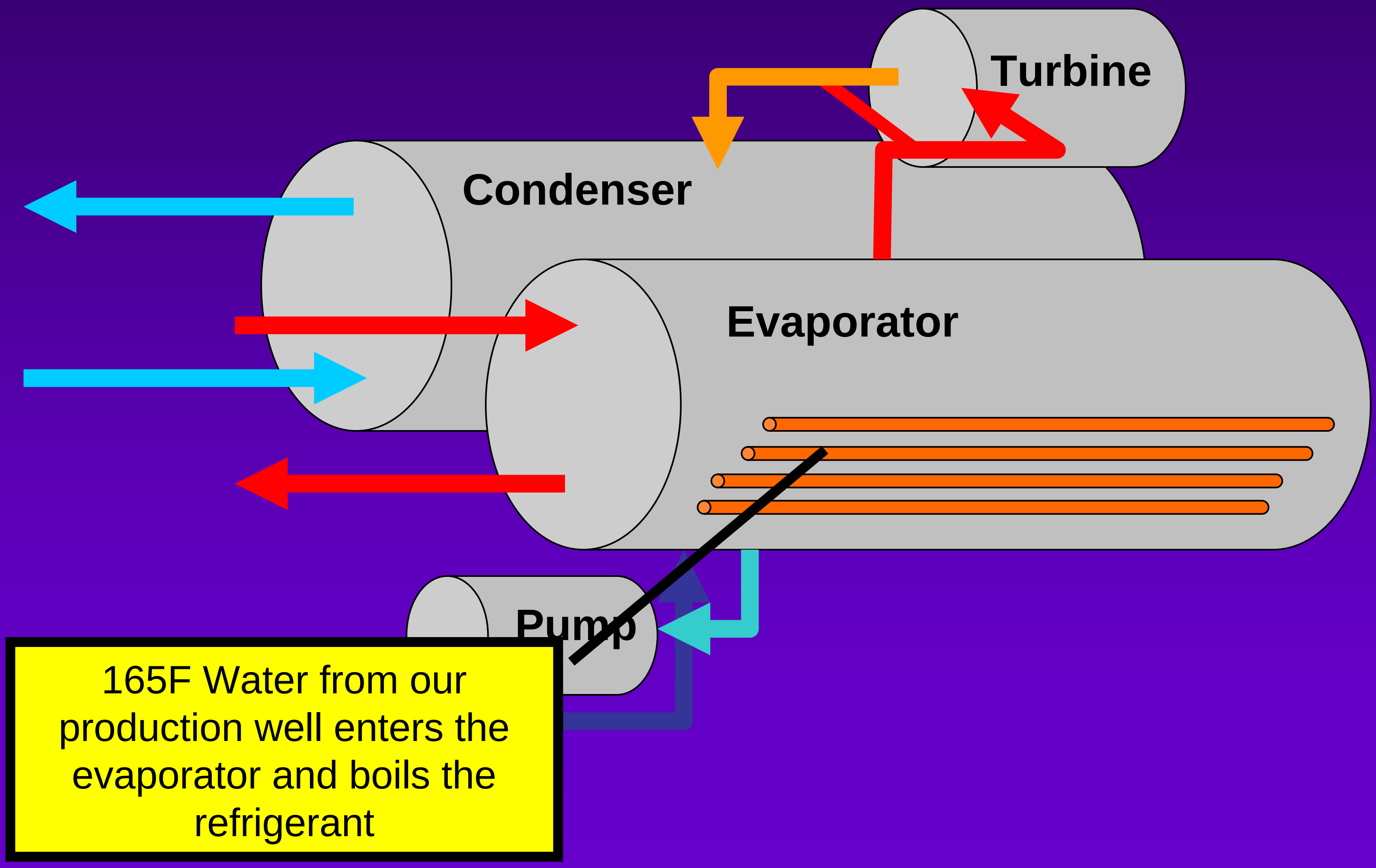
Chena Power Plant



Chena Power Plant

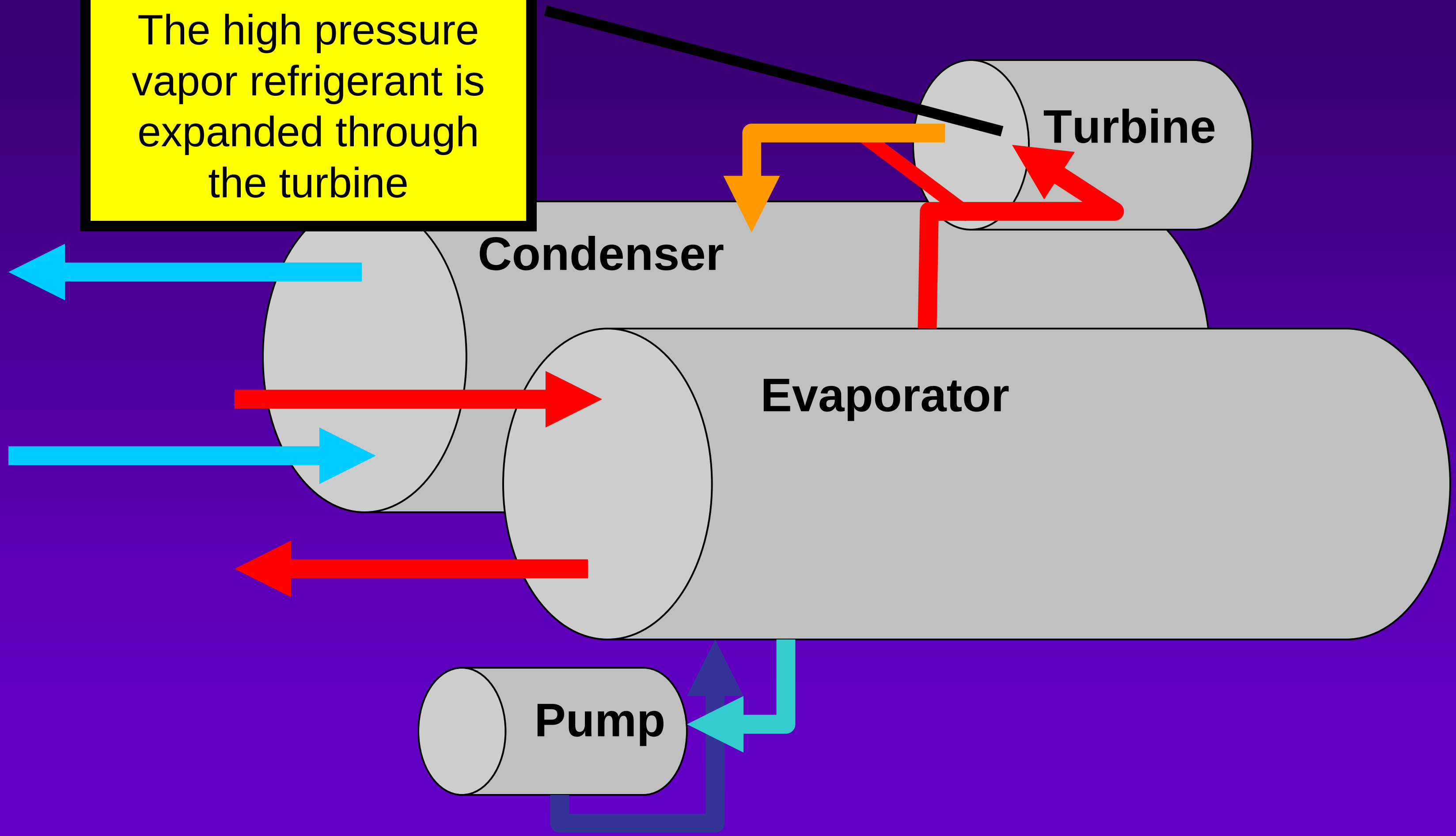


Chena Power Plant



Chena Power Plant

The high pressure vapor refrigerant is expanded through the turbine



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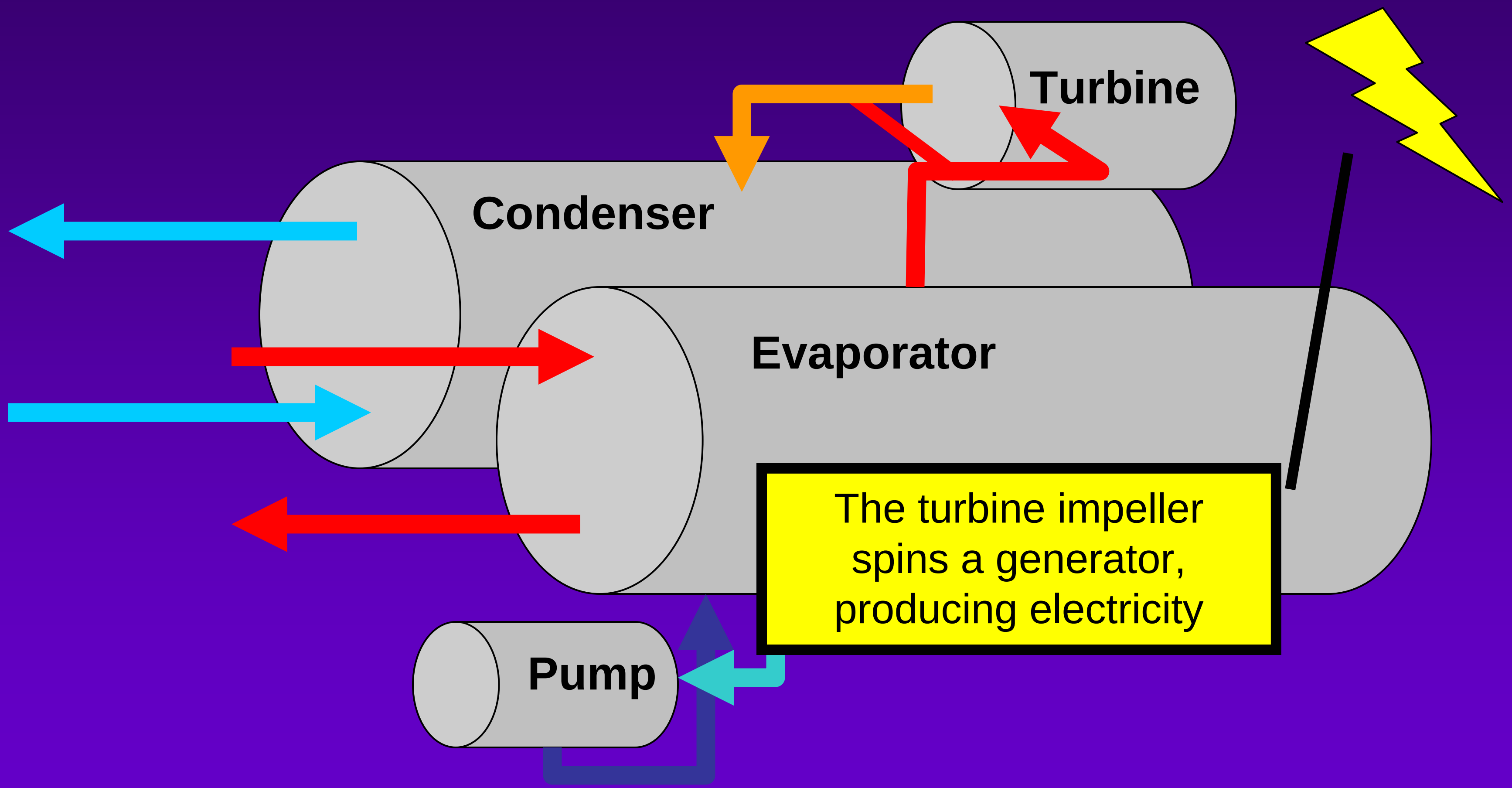
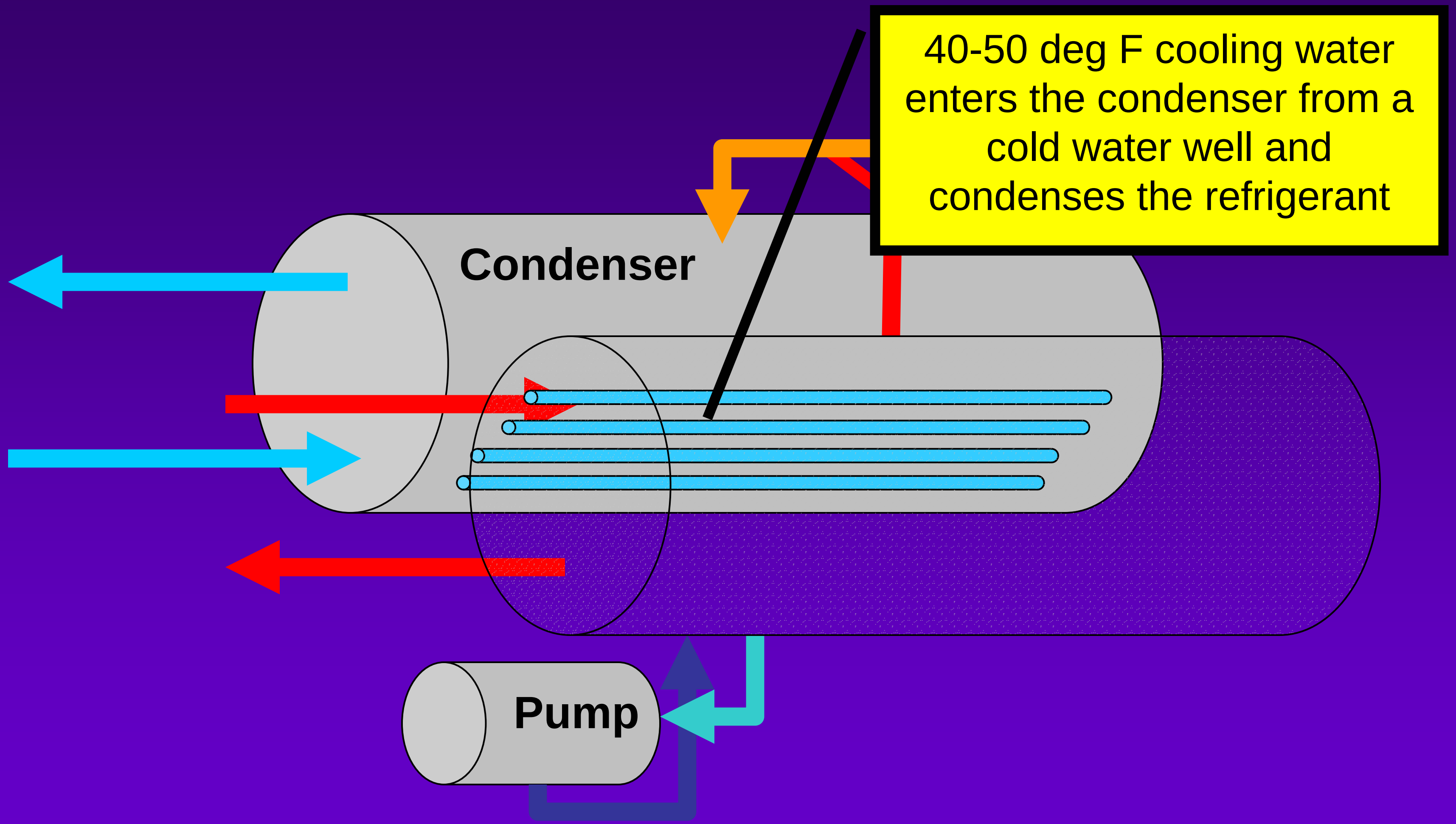
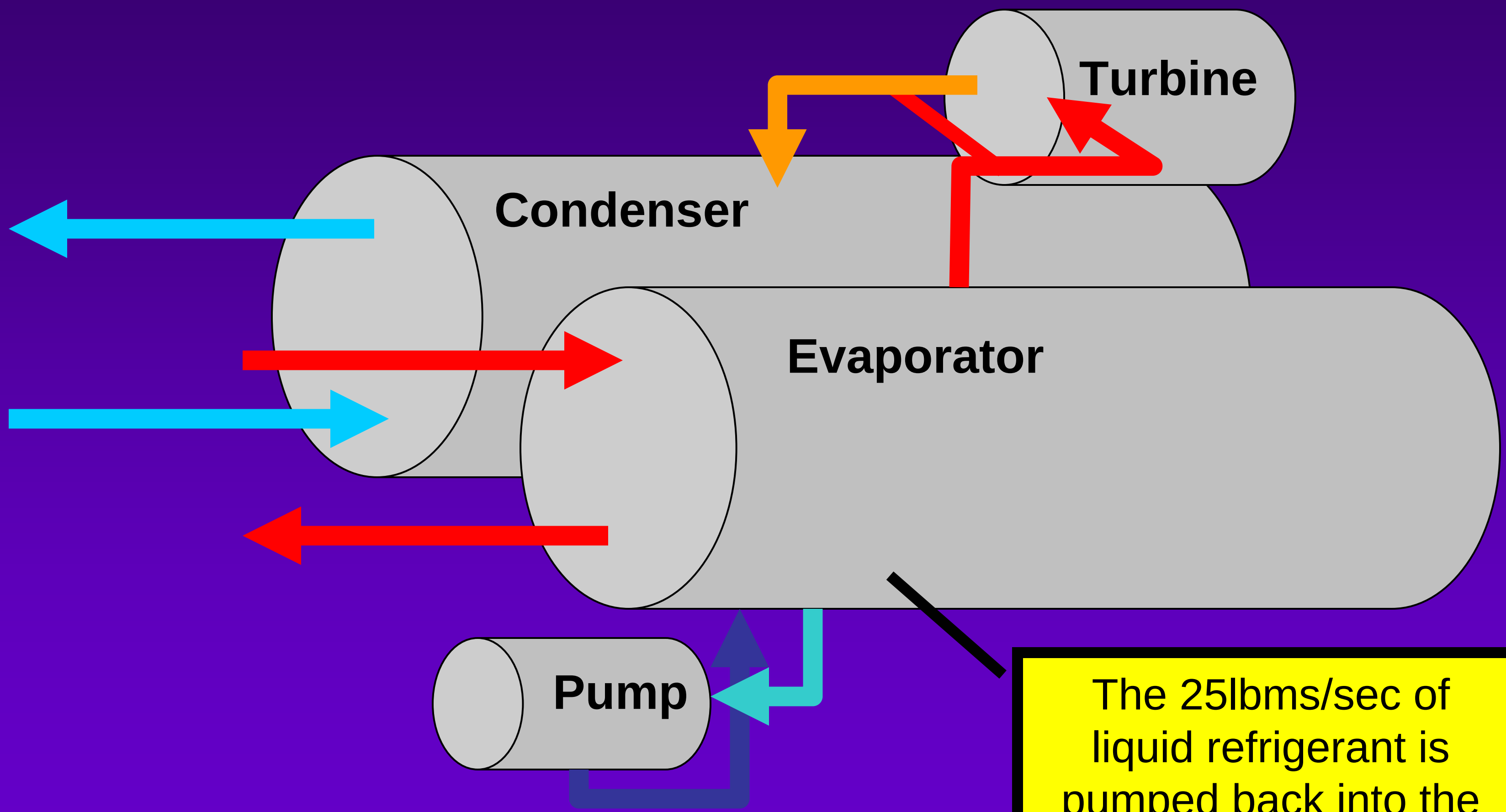


Chena Power Plant



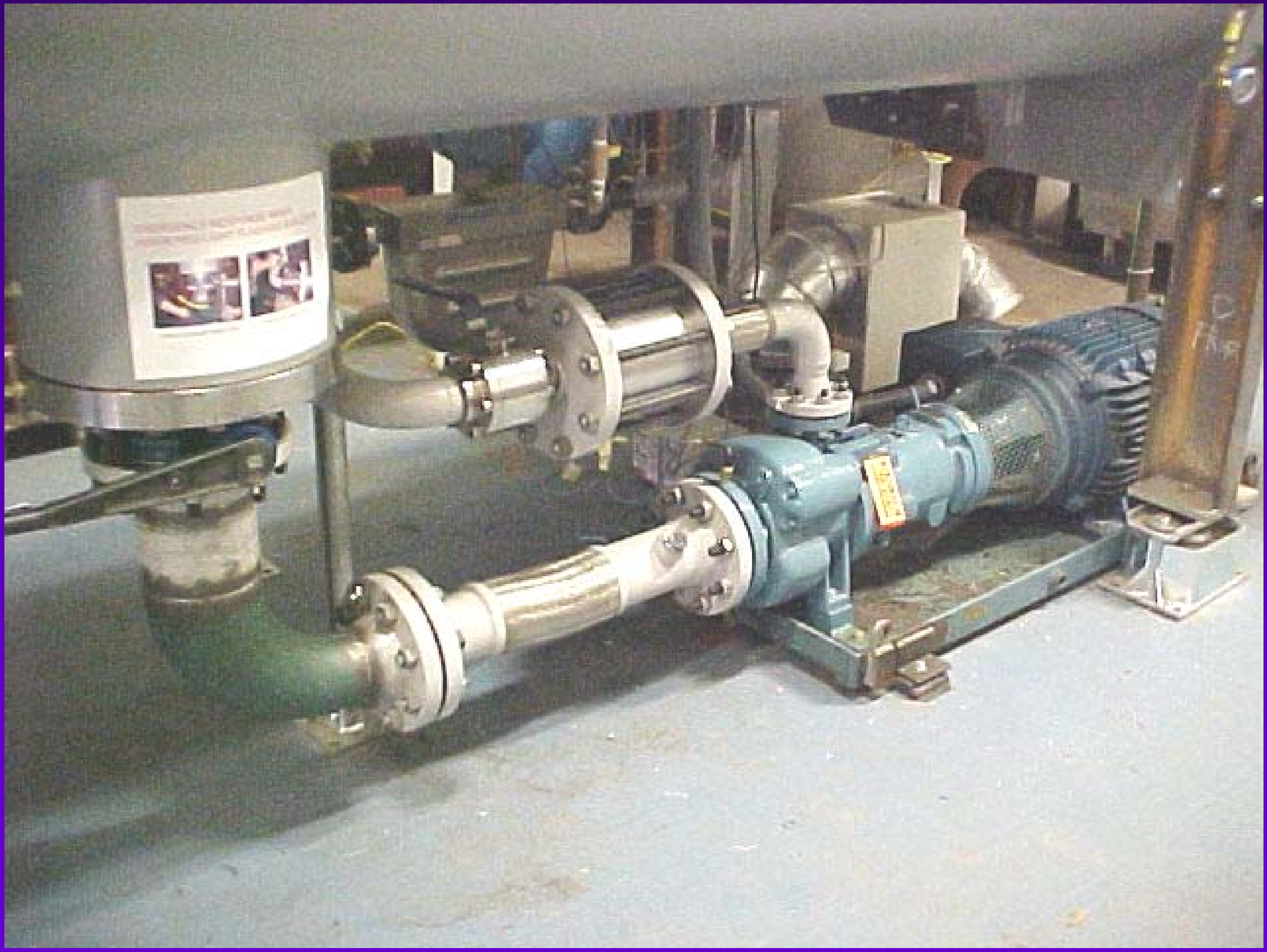
Chena Power Plant



The 25lbms/sec of liquid refrigerant is pumped back into the evaporator at high pressure

Chena Power Plant

Chena Power Plant



Chena Power Plant

CHENA HOT SPRINGS RESORT Alaska

Chena Power Plant

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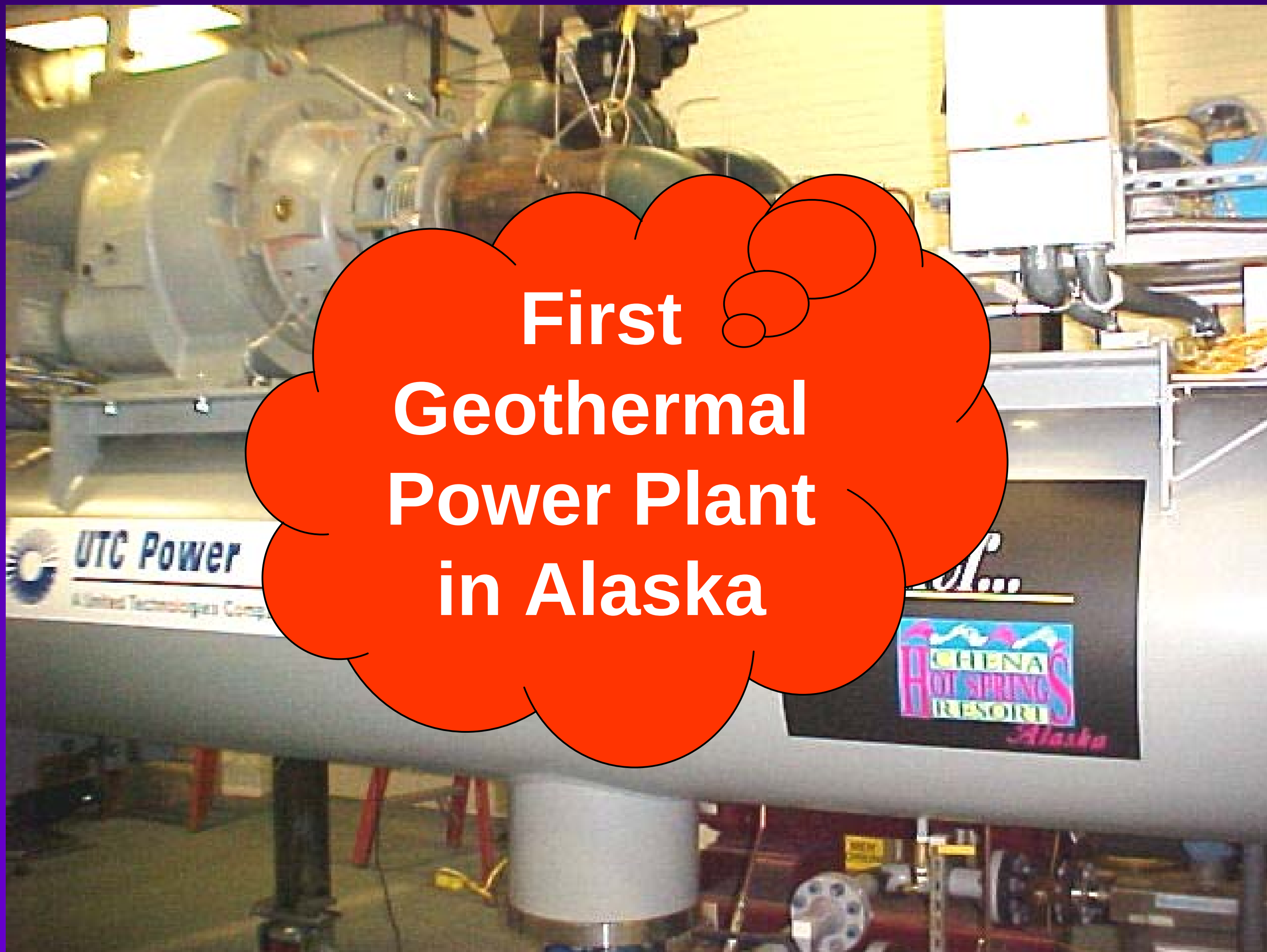
Chena Power Plant



First Geothermal Power Plant in Alaska

Chena Power Plant

CHENA HOT SPRINGS RESORT Alaska

Only new Geothermal Power Plant in US this year

Chena Power Plant

Chena Power Plant

Cold Water Supply

August 20th Official Opening – Chena Geothermal Power Plant

Geothermal Energy is an ideal base load – doesn't depend on sun, wind, rainfall. 99% Availability is common.

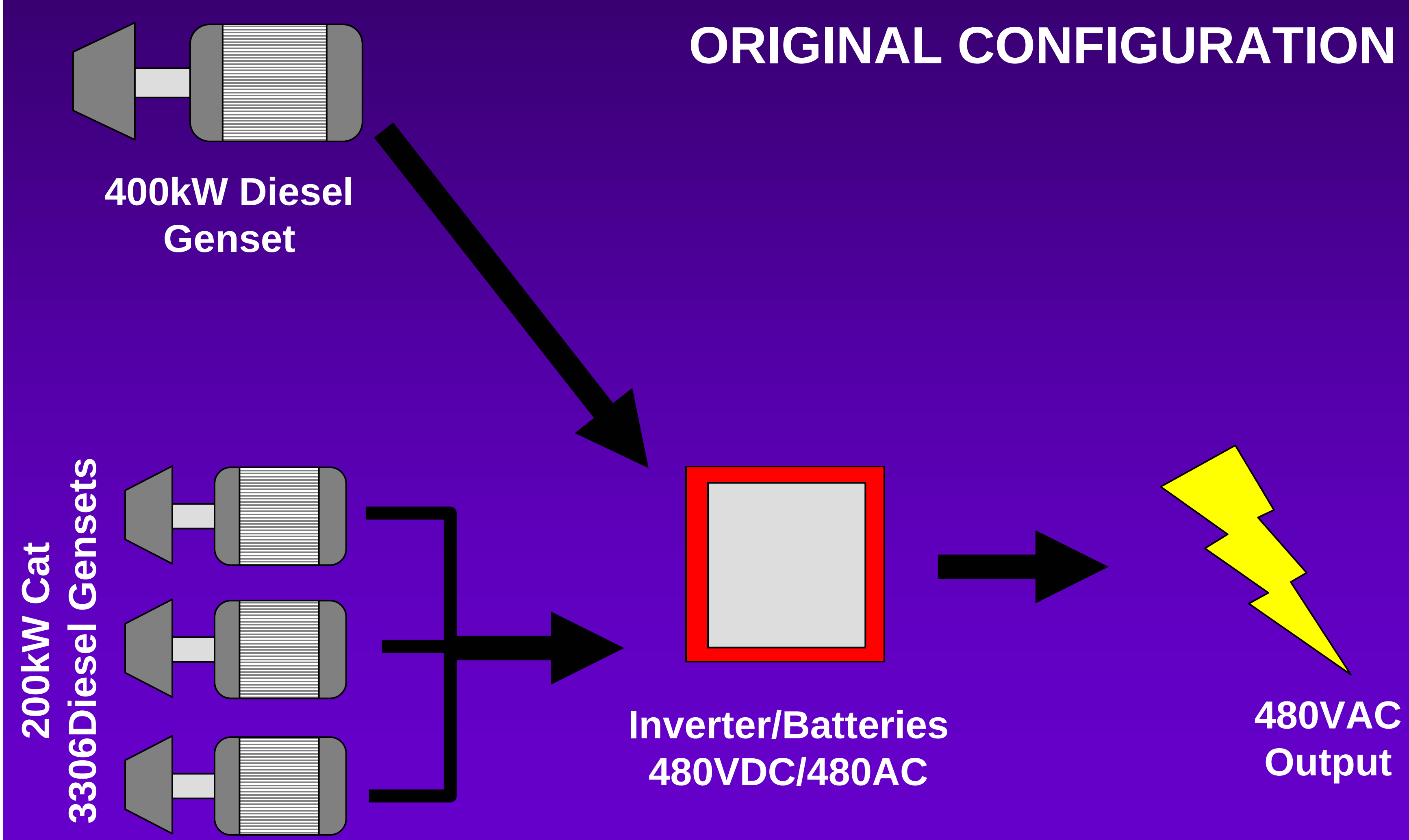
Cannot respond quickly to load fluctuations

Battery and UPS System

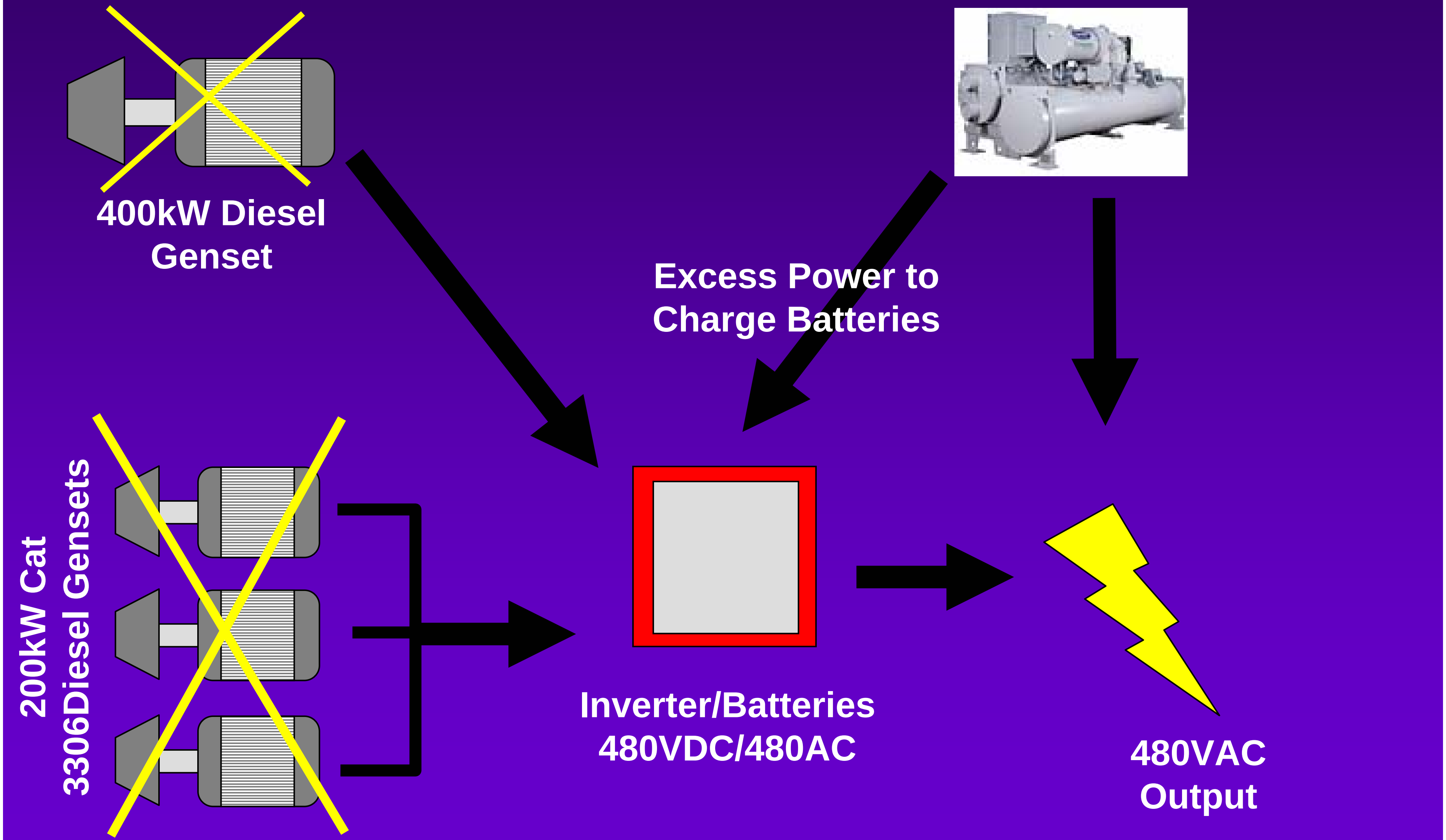
UPS System (MGE)

Batteries 3MW Total

Battery and UPS System



Battery and UPS System



Project Economics

- Power Plant Cost is $1300/kW installed
- Infrastructure costs an additional $1.8 million
- Big expenses included UPS system and 7000ft of pipeline
- Maintenance costs are expected to stay the same or decrease (currently ~$50,000/year)
- Payback period calculated to be 4 to 5 years

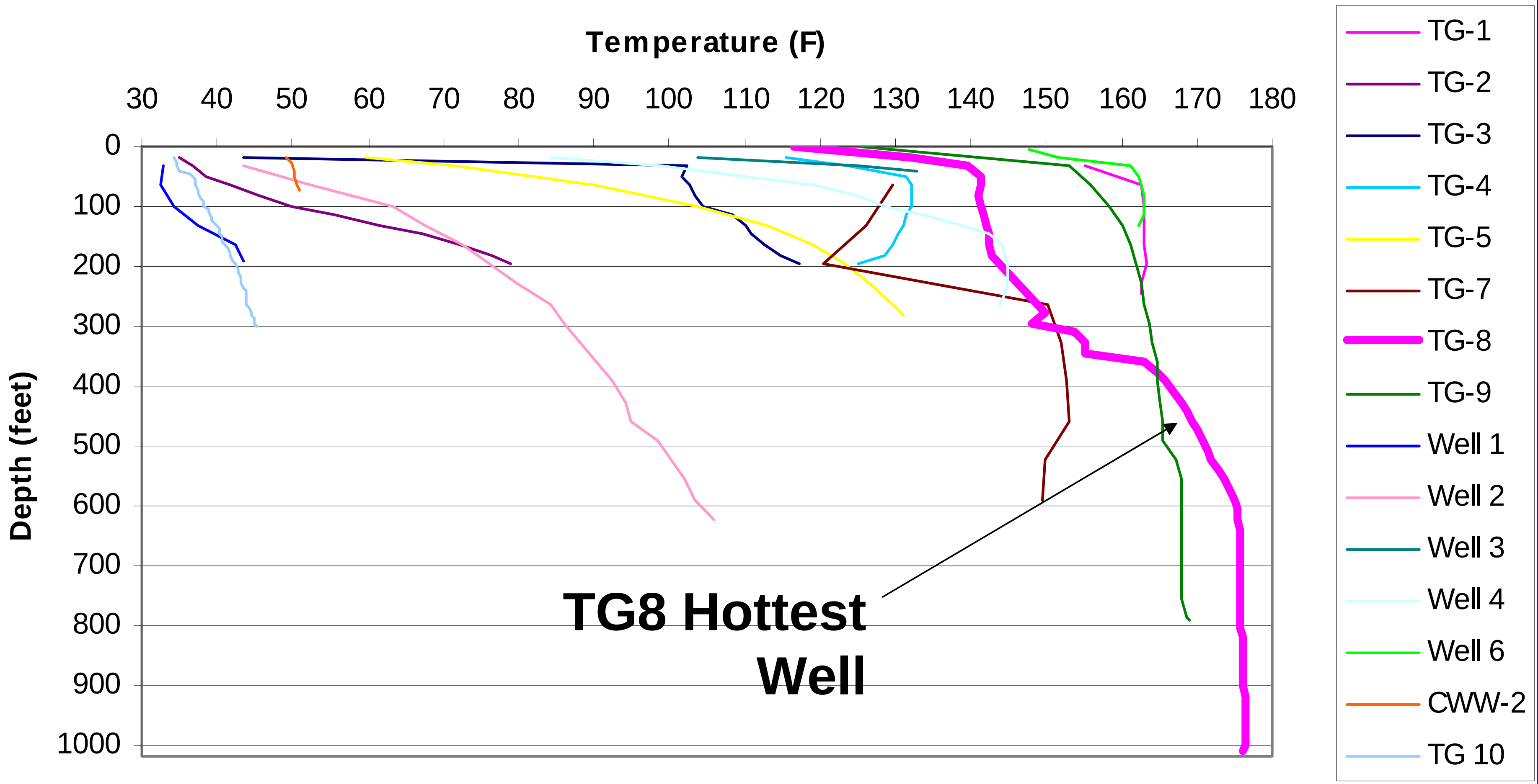
Chena GRED III Project

Joint Chena Hot Springs and DOE Project

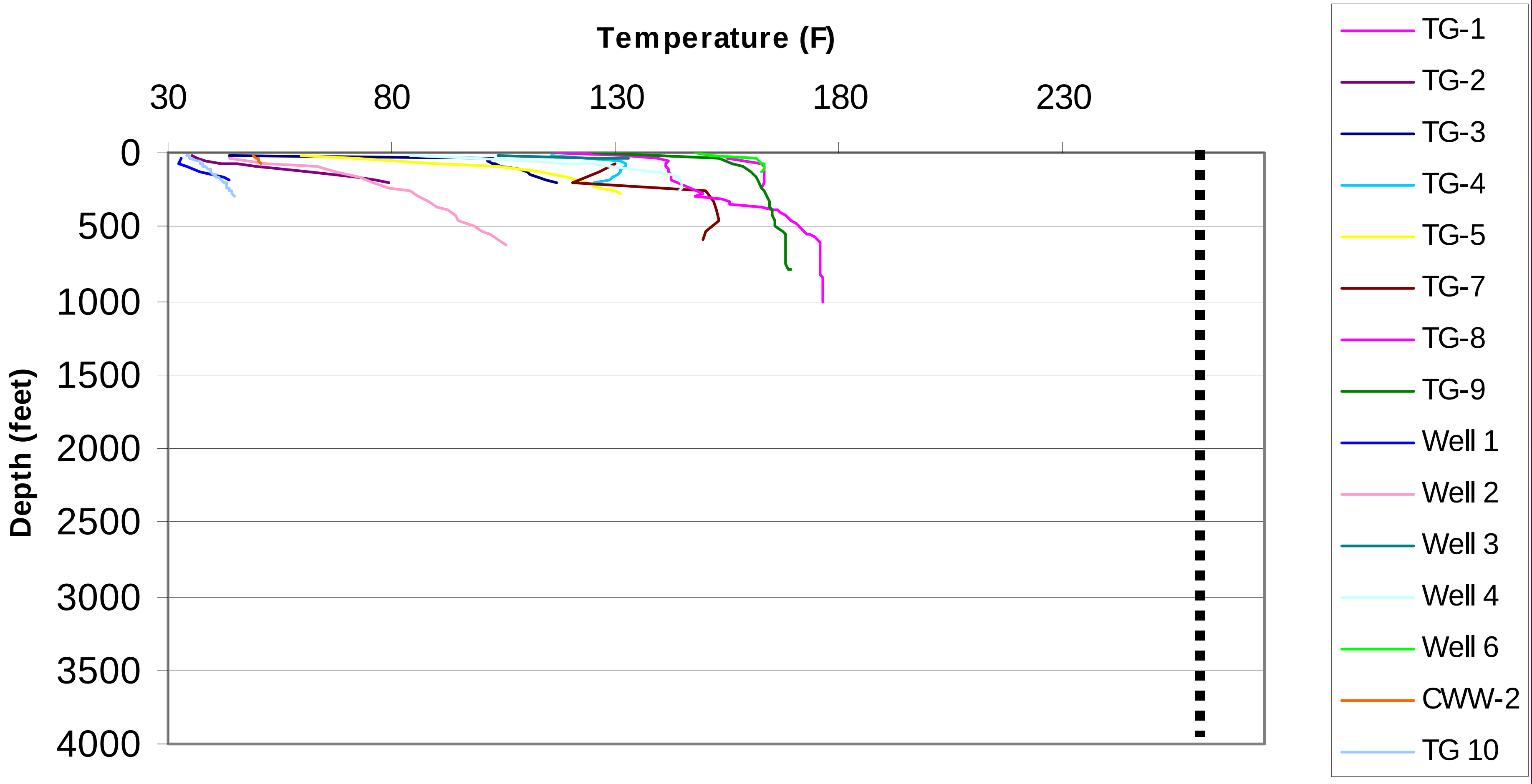
Geothermal Exploration Project to Determine the Power Generating Capacity of the Deep Geothermal Resource

Need to Drill a Deep Hole (two 2500-4000ft) planned for GRED III Phase II to verify geothermal reservoir model at Chena

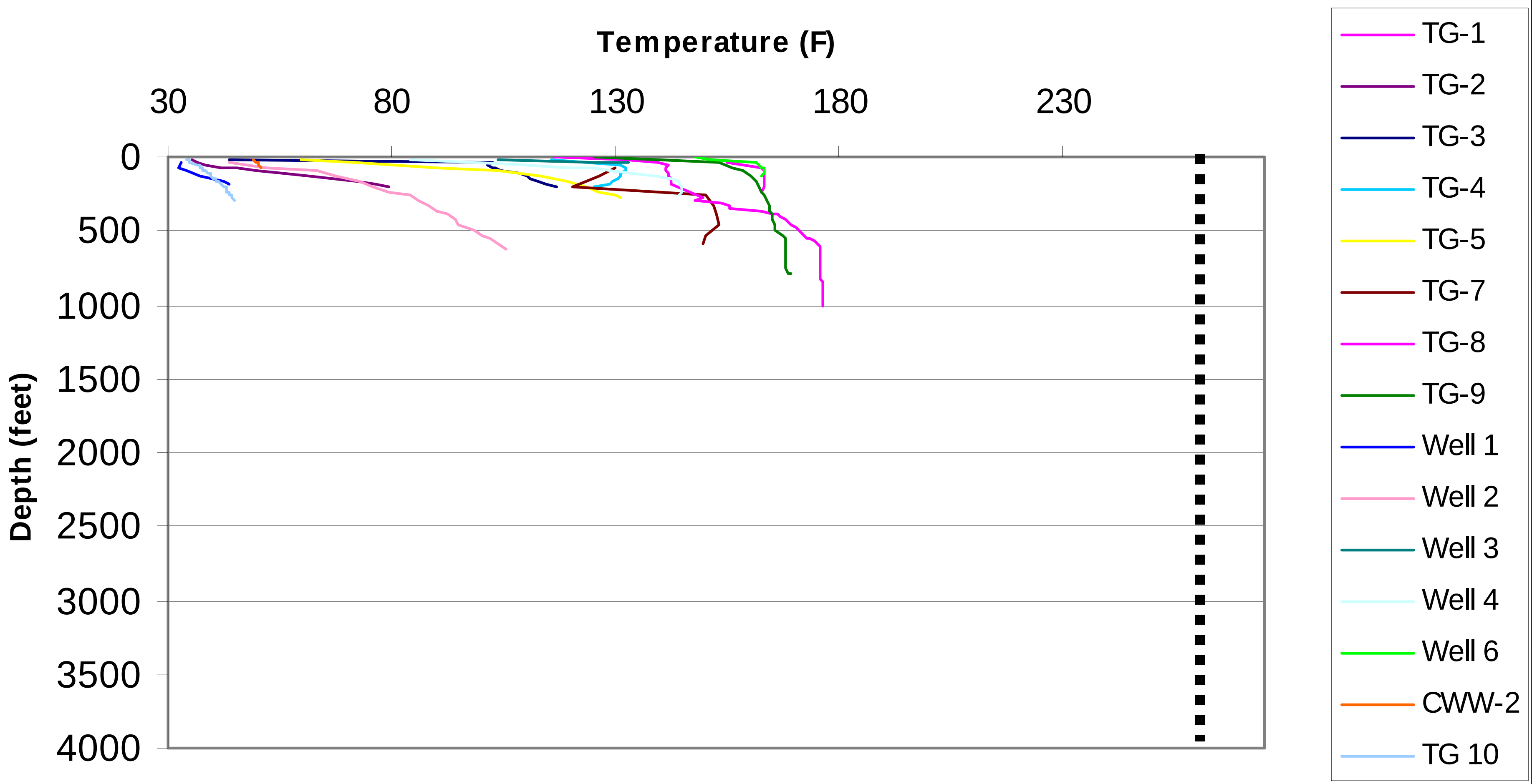
Chena Hot Springs Static Temperature Logs June 2006



Chena Hot Springs Static Temperature Logs June 2006



Chena Hot Springs Static Temperature Logs June 2006




Chena Renewable Energy Center
CHENA
HOT SPRINGS
RESORT
Alaska

Solar Power

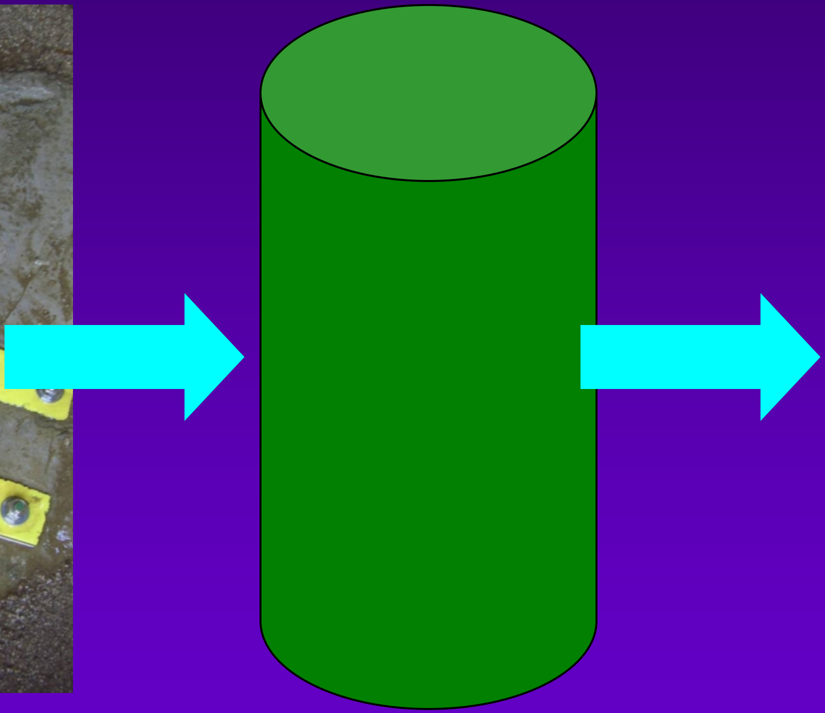
Daily Tours

Water Power


CHENA
HOT SPRINGS
RESORT
Alaska

Water Power

Water Ram Pump

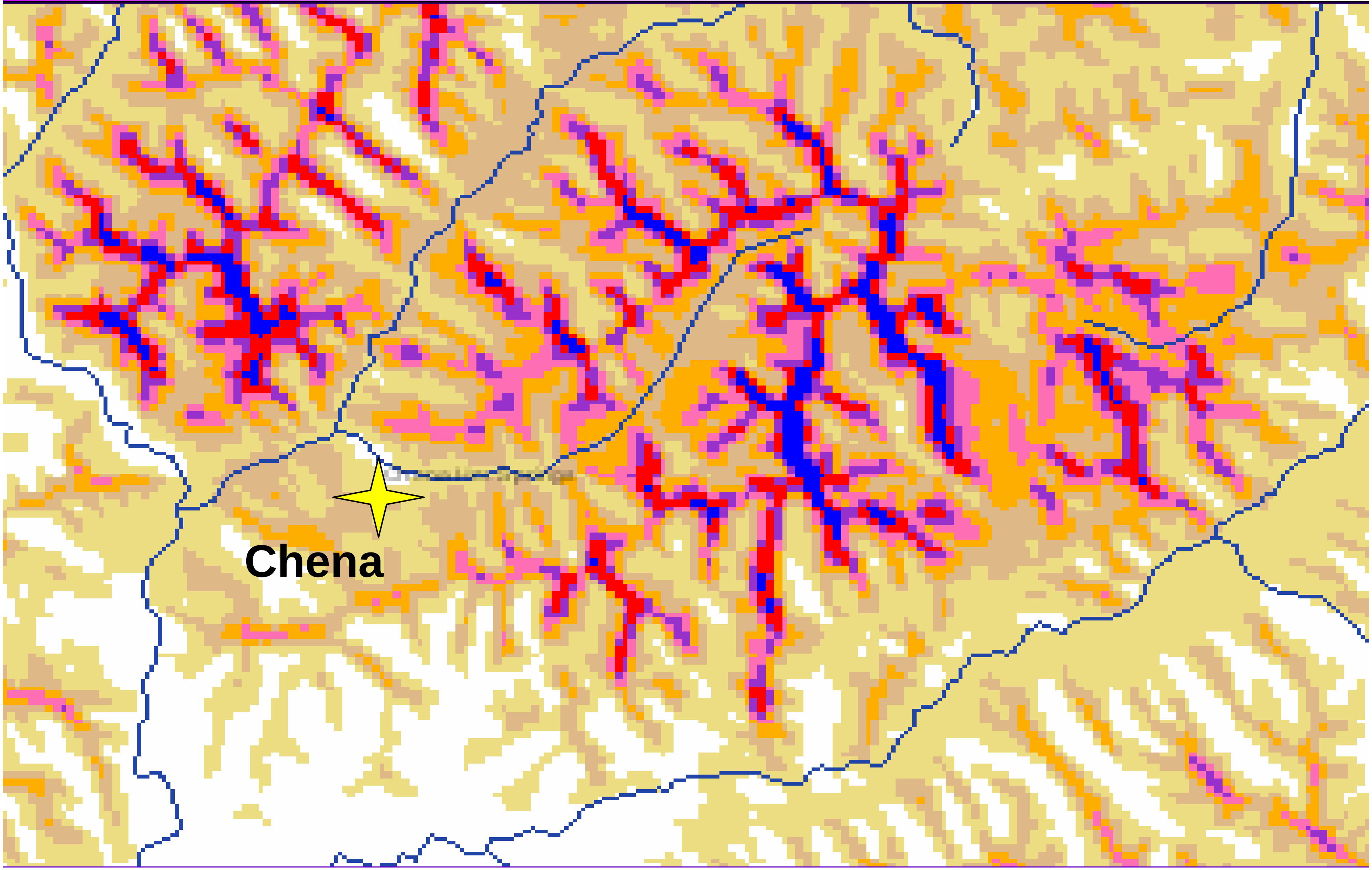


Water Ram pumps water from nearby creek (~1200gpd)

4200 gallon storage tank delivers water at 10psi to gardens

Drip Irrigation used to supply water to all production areas

Wind Power



Wind Power

What is Renewable Energy Alaska Project (REAP)?

- An Alaskan coalition of small and large electric utilities and utility interests, environmental groups, consumer groups, businesses, Alaska Native organizations and energy agencies with the goal of “increasing the production of renewable energy in Alaska.”
- Alaska’s first and only education and advocacy group for renewable energy

REAP's Strategies

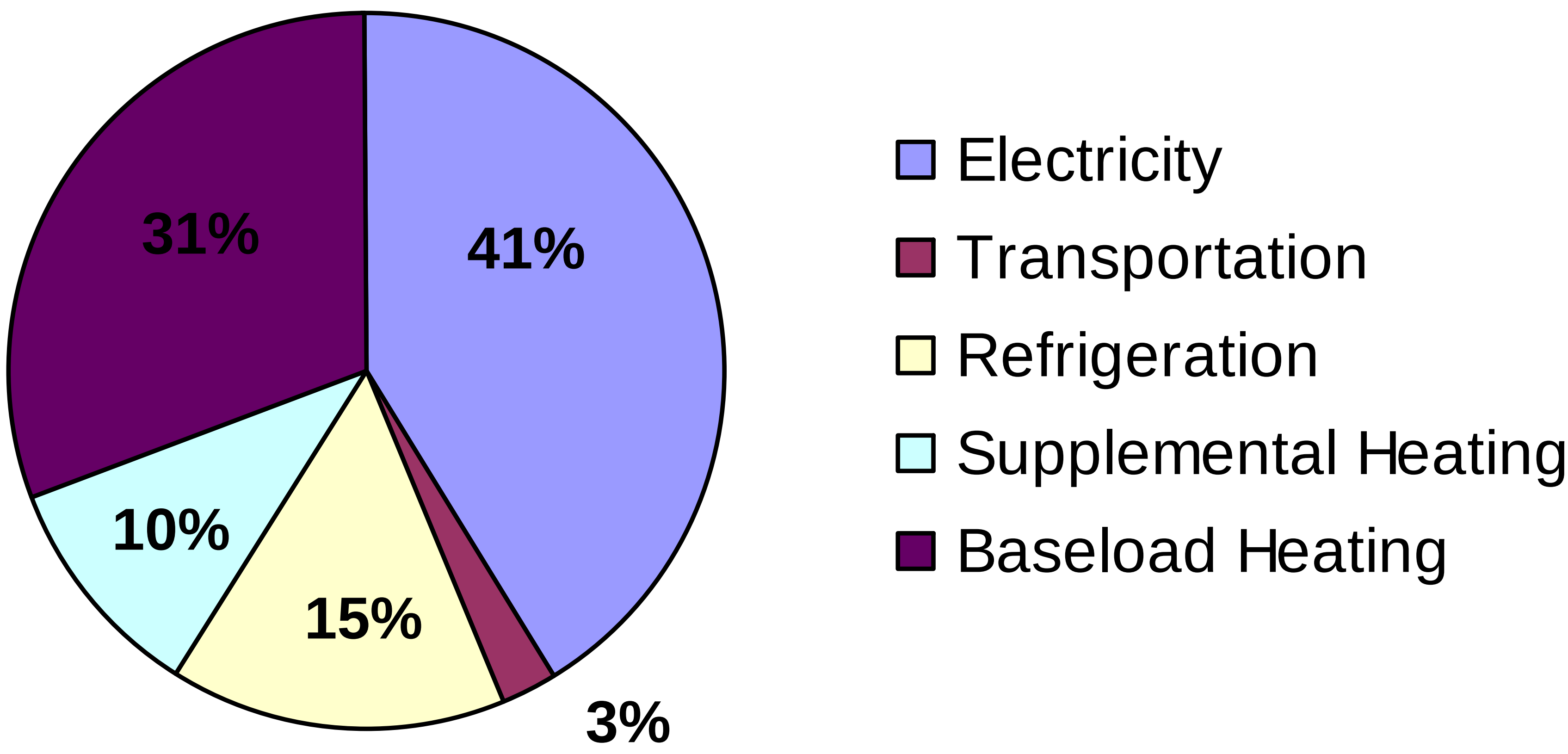
- Put viable renewable energy projects 'in the ground'
- Advocate for statewide policies that promote renewables
- Grow the market for renewable energy
- Foster and demonstrate stakeholder unity in support of renewable energy
- Promote energy efficiency

REAP Director Members

Chugach Electric Association (CEA)
Municipal Light and Power (ML & P)
Golden Valley Electric Association (GVEA)
Homer Electric Association (HEA)
Kotzebue Electric Association (KEA)
Alaska Village Electric Cooperative (AVEC)
TDX Power
Alaska Power Association (APA)
Alaska Power and Telephone
Sierra Club
Alaska Center for the Environment
Alaska Conservation Alliance
Alaska Public Interest Research Group (AkPIRG)
Rural Alaska Community Action Program (RurALCAP)
Green Star
Chena Hot Springs
PowerCorp Alaska, Inc.
Siemens Building Technologies
Alaska Inter-Tribal Council
Aleutian/Pribilof Islands Association (APIA)
Yukon River Inter-Tribal Watershed Conference

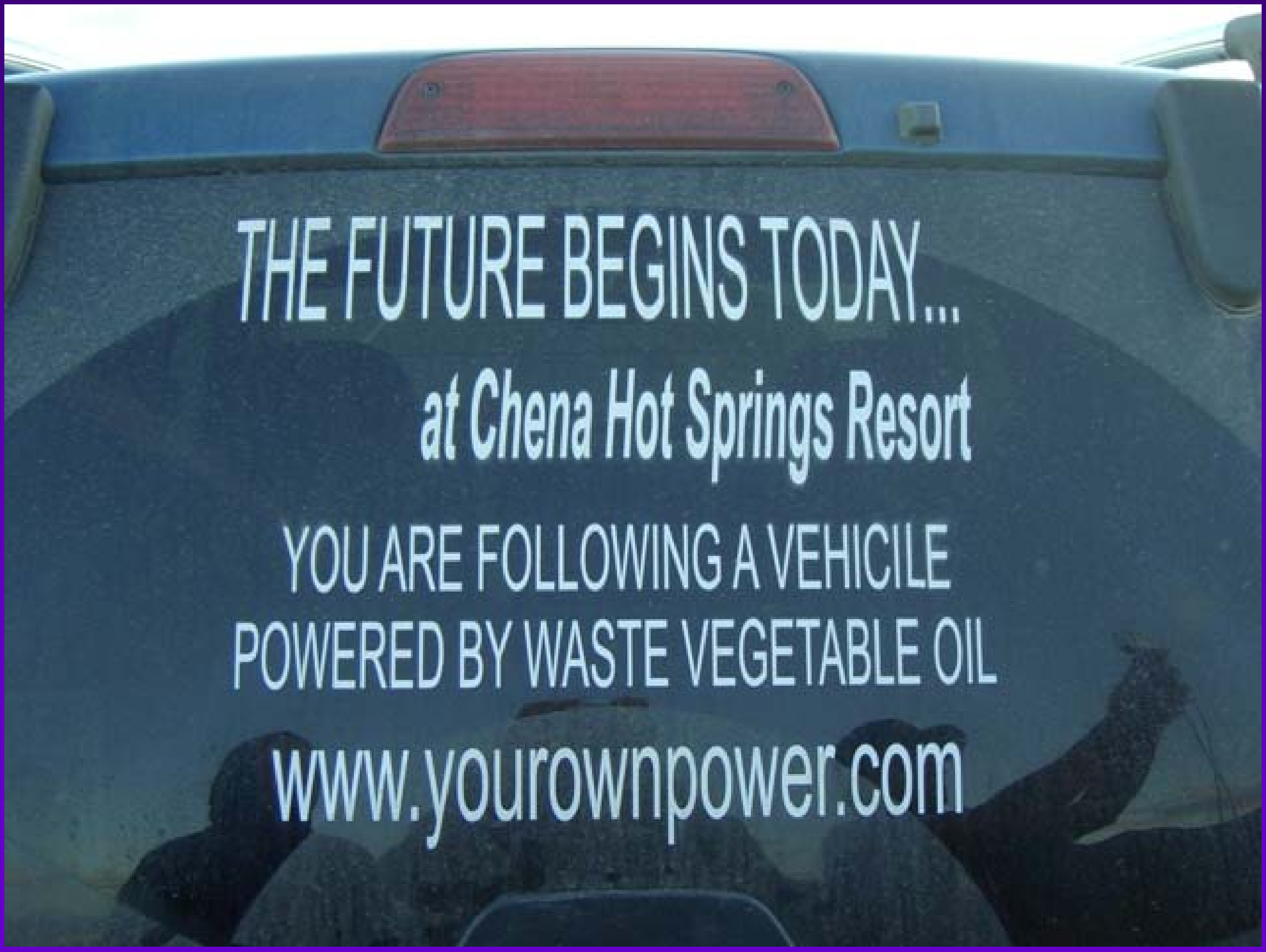
What's next …

Energy Needs at Chena Hot Springs



Alternative Fuels

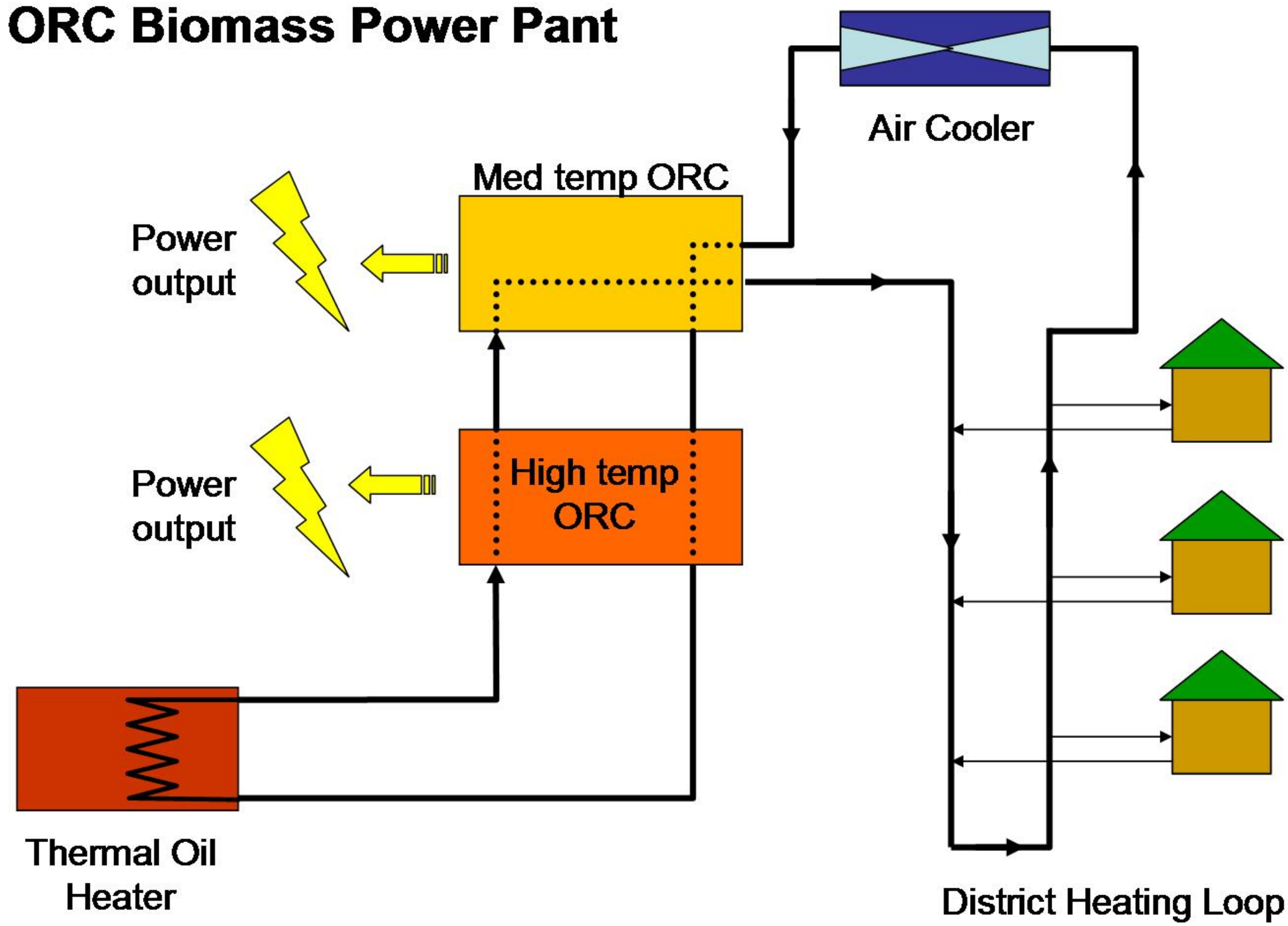
Alternative Fuels – Used Vegetable Oil

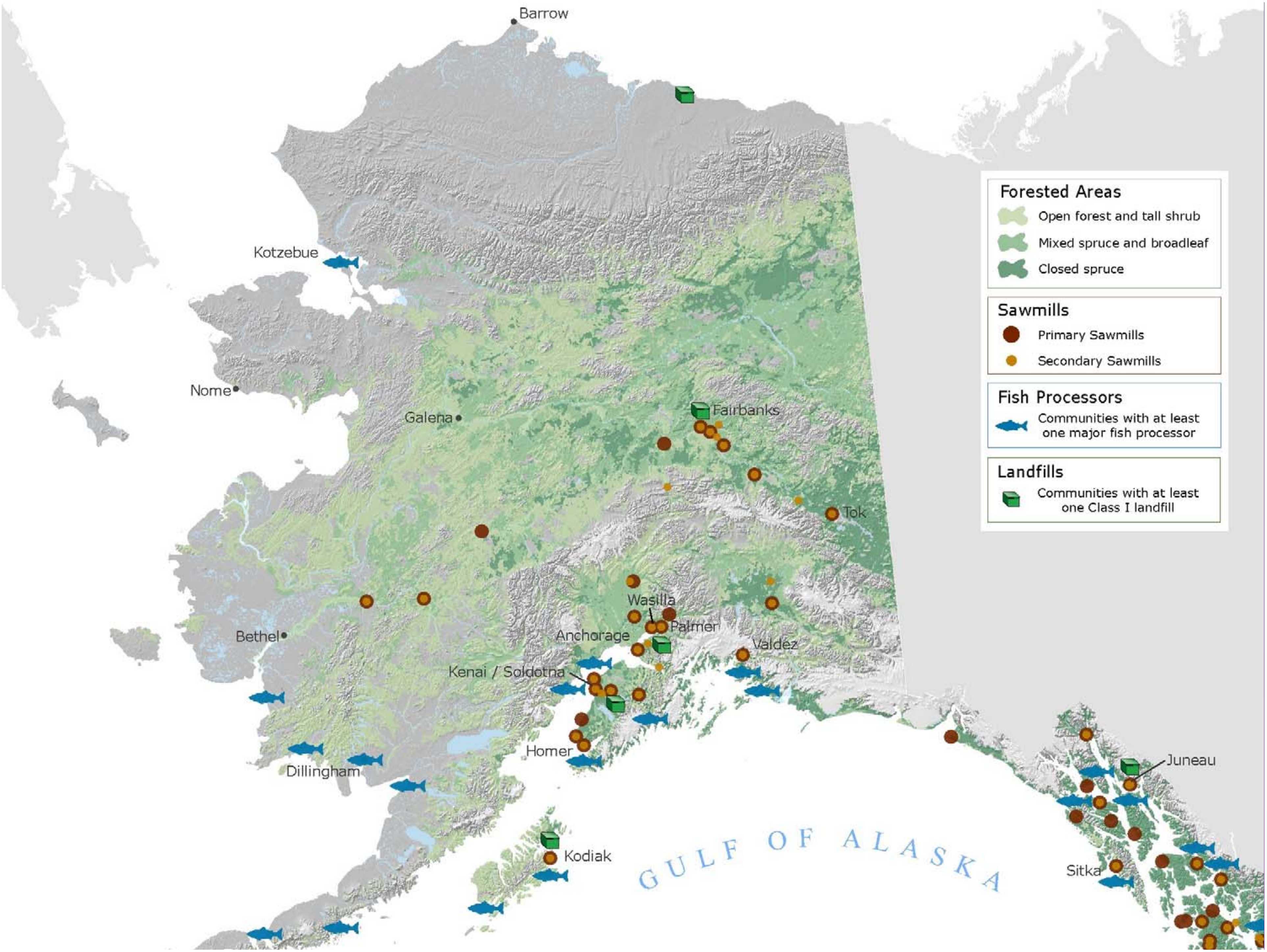


Hydrogen

CHENA HOT SPRINGS RESORT Alaska

200kW Biomass System





Barrow
Kotzebue
Nome
Galena
Fairbanks
Tok
Bethel
Wasilla
Palmer
Anchorage
Valdez
Kenai / Soldotna
Homer
Dillingham
Kodiak
GULF OF ALASKA
Juneau
Sitka
Forested Areas
Open forest and tall shrub
Mixed spruce and broadleaf
Closed spruce
Sawmills
Primary Sawmills
Secondary Sawmills
Fish Processors
Communities with at least one major fish processor
Landfills
Communities with at least one Class I landfill

Wood – the old standby

Photo Credit: UAF Archives

Northern Commercial woodpile in Fairbanks

Willow Biomass

- Successful biomass crop in Europe and in test plot at New York University
- Could be used in rural Alaska for heating and power generation
- Provides excellent moose and caribou habitat
- Already grows successfully in Alaska!!

Willow Biomass

New York University 500 acre willow biomass test plot

Project Champions

Connie & Bernie Karl

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