

# From Hot Water to Hydrogen

## *Bringing Geothermal Power to Alaska*



*Presented by: Bernie Karl*

**SMU Geothermal Conference June 12<sup>th</sup>, 2007**



# Chena Hot Springs





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- **Semi remote site**
- **Electric Power 30¢/kWhr**
- **Load 180kW-380kW**





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- **Load 180kW-380kW**

- **\$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***

## ***Chena Hot Springs MISSION:***

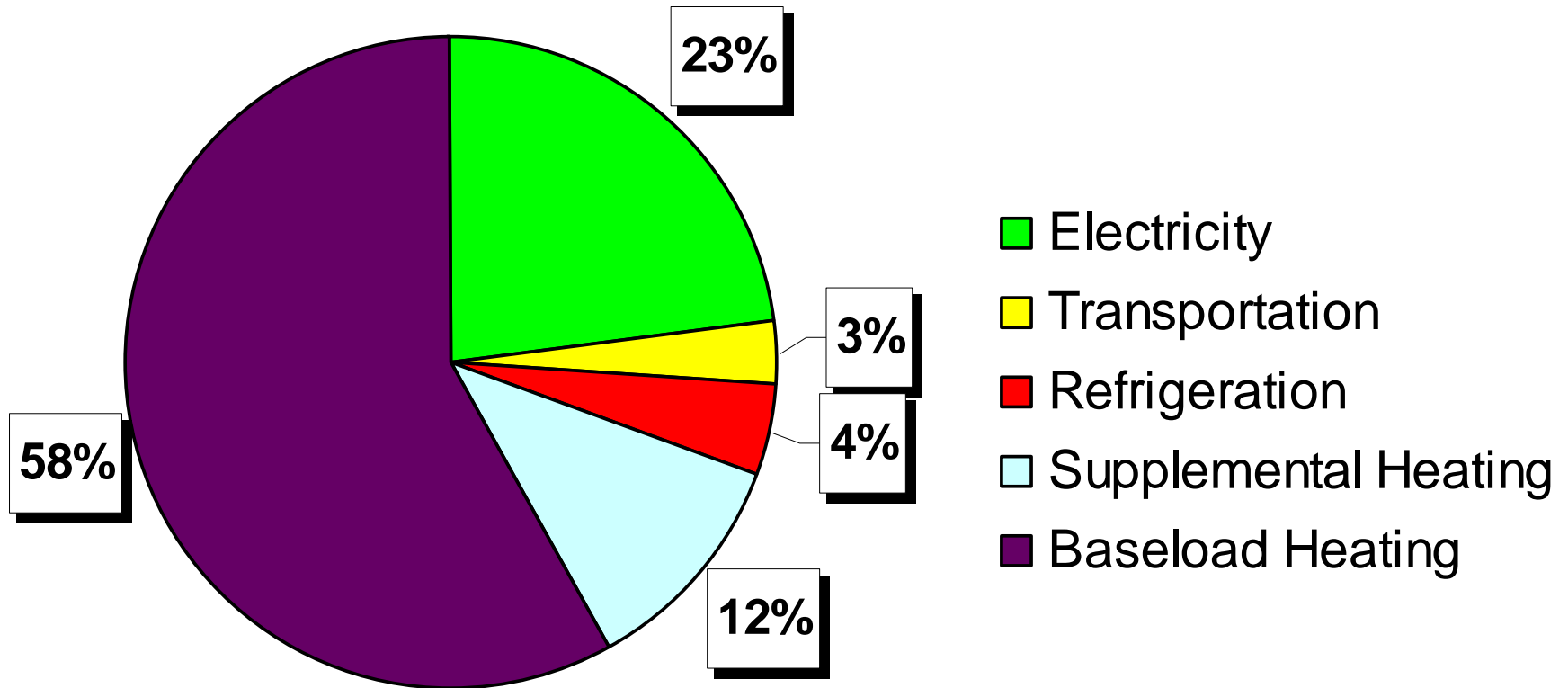
***To encourage renewable energy  
and sustainable community  
development throughout Alaska***

***To make Alaska a leader in  
renewable energy development***

# Forming Partnerships with:

- *University of Alaska (Horticulture, Geophysical Institute, Mining, Geology)*
- *Southern Methodist University*
- *Department of Energy*
- *Alaska Energy Authority*
- *Denali Commission*
- *United Technologies Corporation*
- *Golden Valley Electric Association*
- *REAP (Renewable Energy Alaska Project)*

## Energy Use at Chena Hot Springs (total 850 kW<sub>eq</sub>)





# *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 costs



*Moose Lodge, 20,000ft<sup>2</sup> 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



























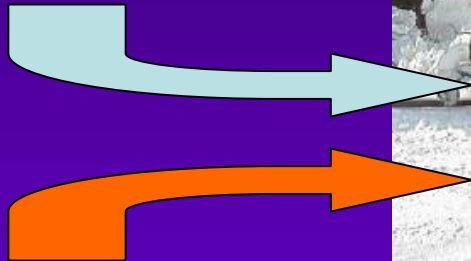




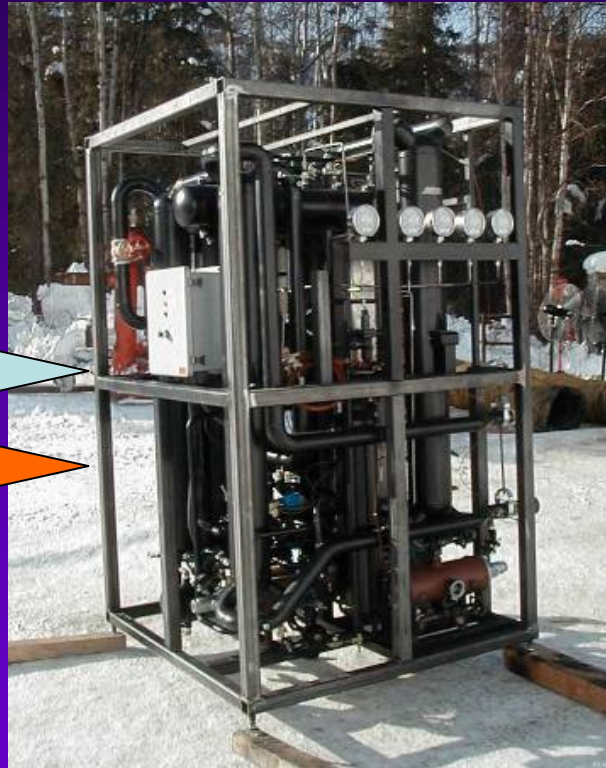
# CHENA HOT SPRINGS ABSORPTION CHILLER



Monument Creek Provides Cooling Water (~40F)



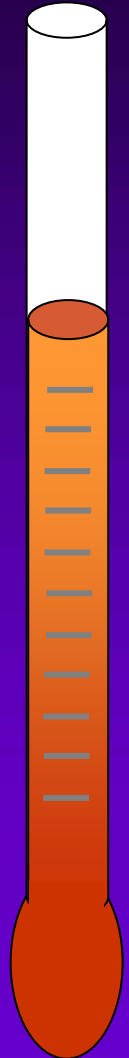
Geothermal Wells Provide Hot Water (~165F)



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

# Conventional Wisdom for Absorption Chilling & Power Generation Cycles:

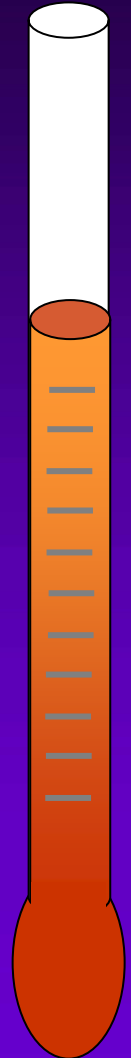
$$T \geq 230^{\circ}\text{F}$$





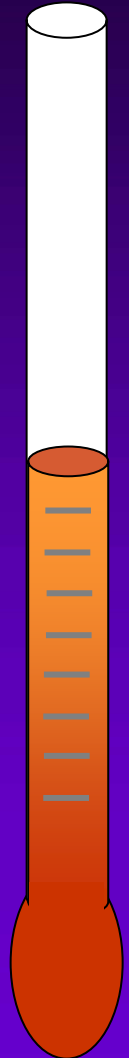
# Conventional Wisdom for Absorption Chilling & Power Generation Cycles:

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



# Conventional Wisdom for Absorption Chilling & Power Generation Cycles:

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



# Chena Geothermal Power Plant





# 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

## United Technologies Corporation (UTC)



**UTC Research Center**  
– Technology  
Advancement



**UTC Power**  
On-site &  
Transportation



**Hamilton Sundstrand**  
Aerospace & Industrial



**Sikorsky**  
Helicopters

# United Technologies



**Carrier**  
Heating, Cooling  
& Refrigeration

## Pure Cycle 200 Product Development



**UTC Research Center**  
– Technology  
Advancement



**UTC Power**  
On-site &  
Transportation

# Chena Geothermal Power Plant

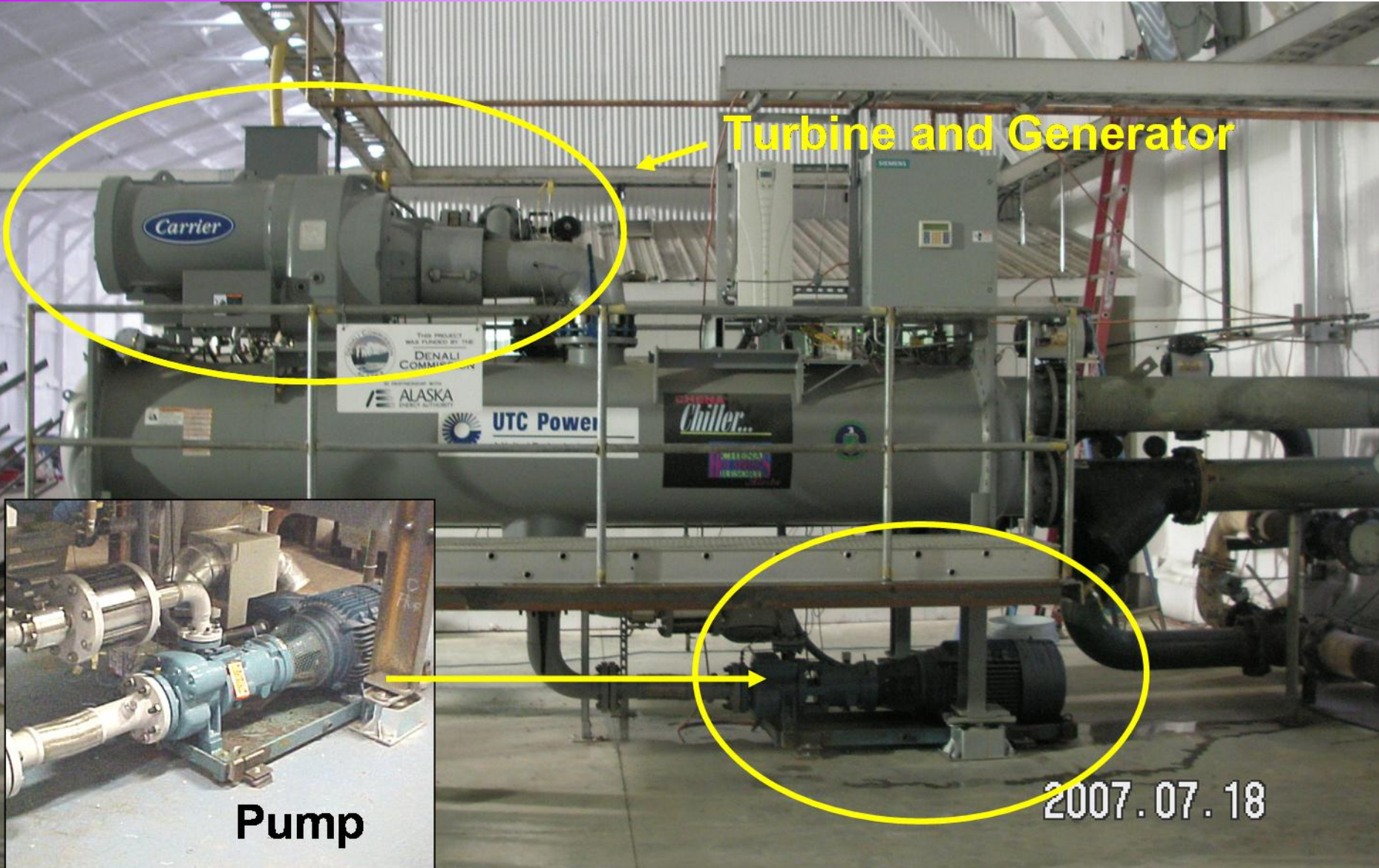


- 400kW net; installed in 2006
- Uses 1060 gpm of 165°F water
- Air and water cooled
- Reduced local cost of power from 30¢ to 5¢
- Total project cost \$2.2 million
- Efficiency <10%





# Chena Power Plant



Turbine and Generator

Pump

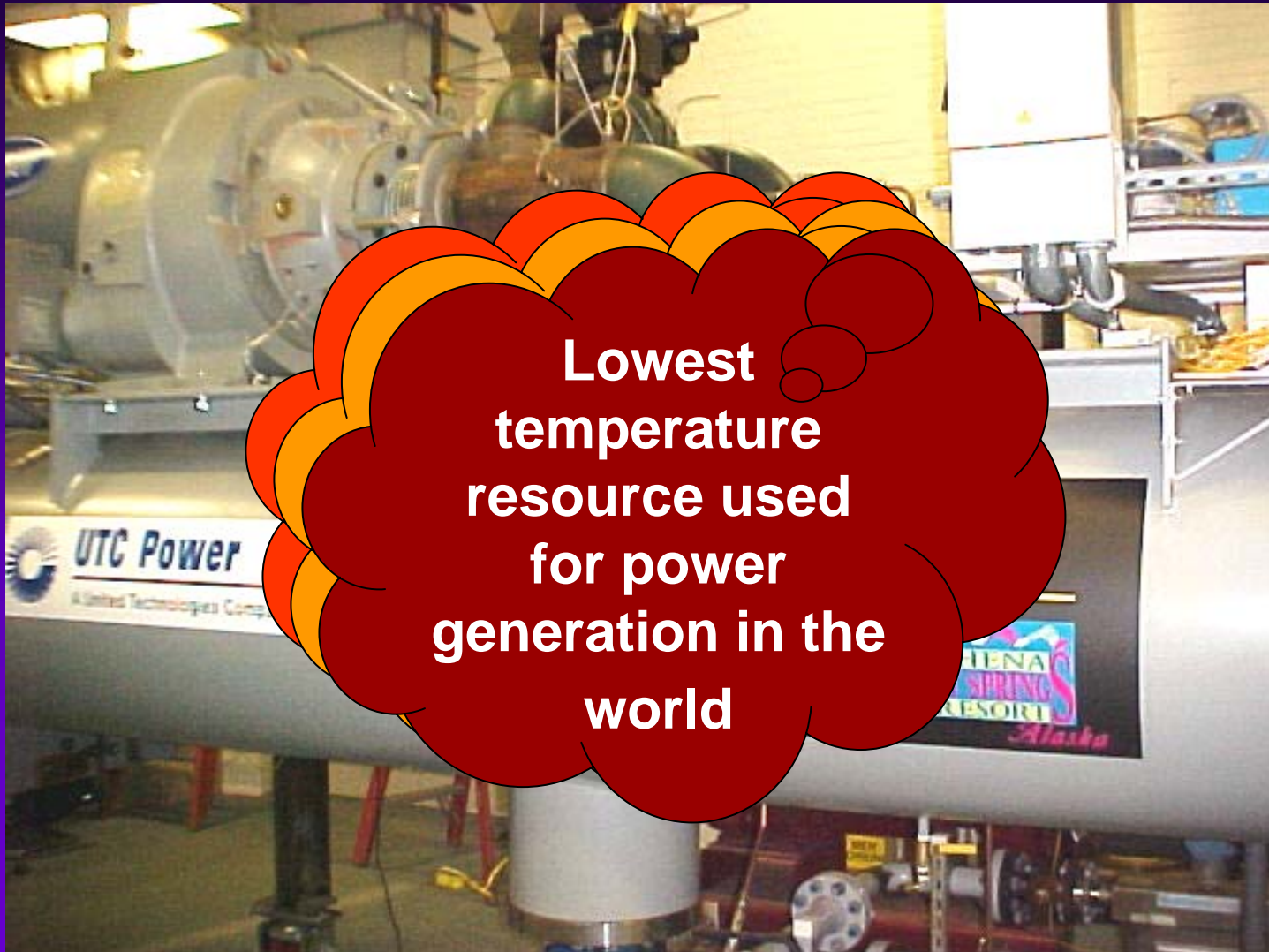
2007.07.18

# Chena Power Plant





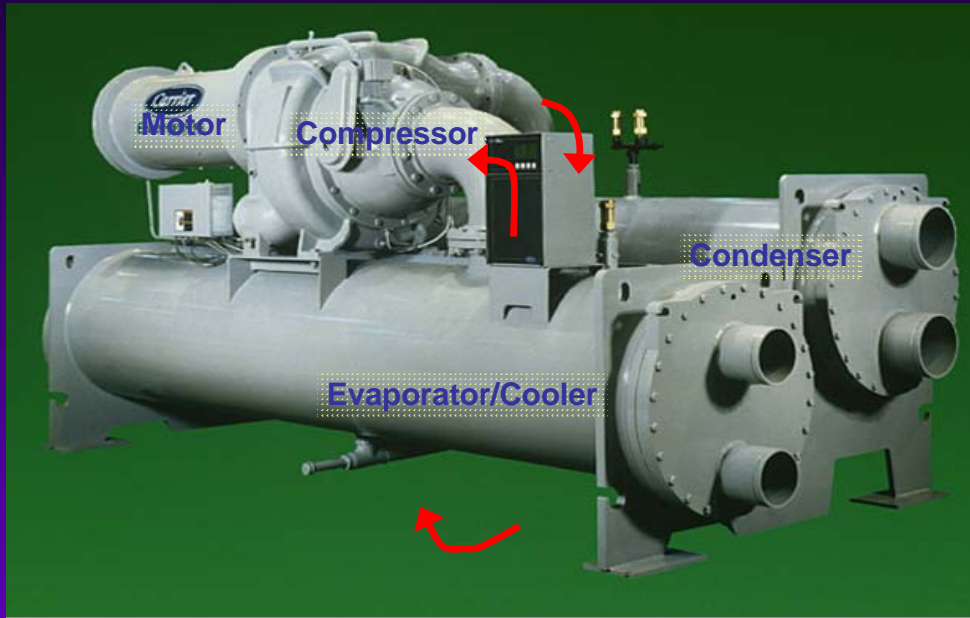
# Chena Power Plant



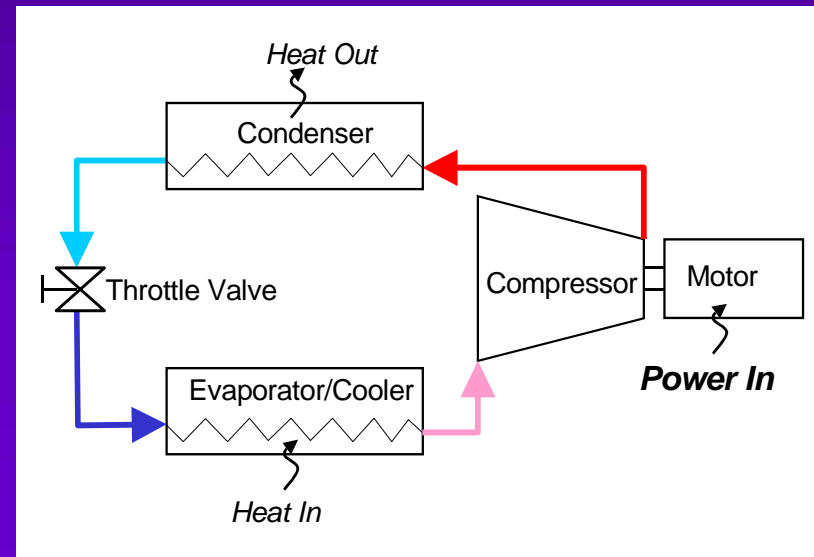
**Lowest  
temperature  
resource used  
for power  
generation in the  
world**



# Carrier Chiller

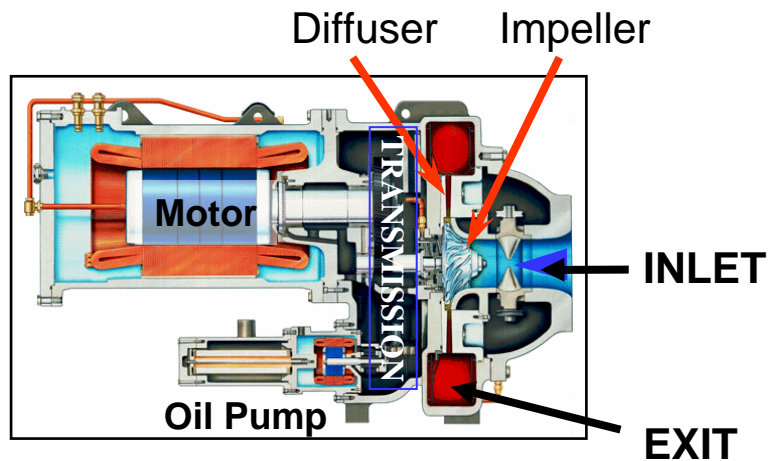
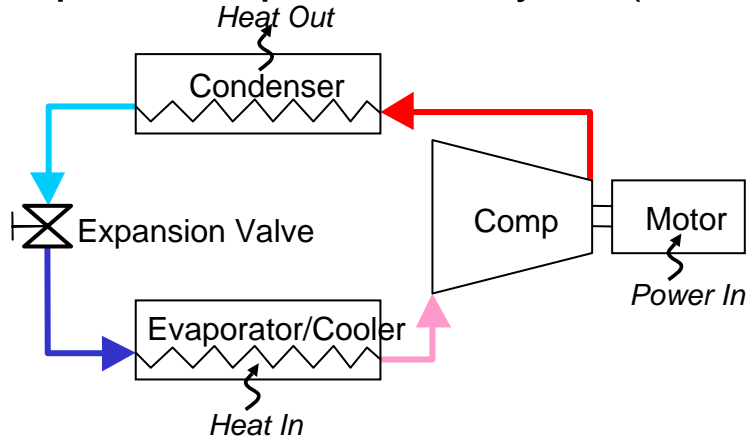


**Refrigeration Cycle**



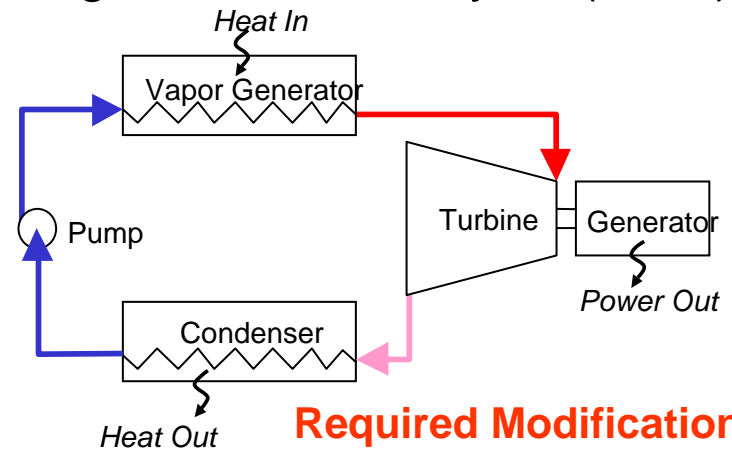
# Carrier Turbine Generator

## Vapor Compression Cycle (VCC)

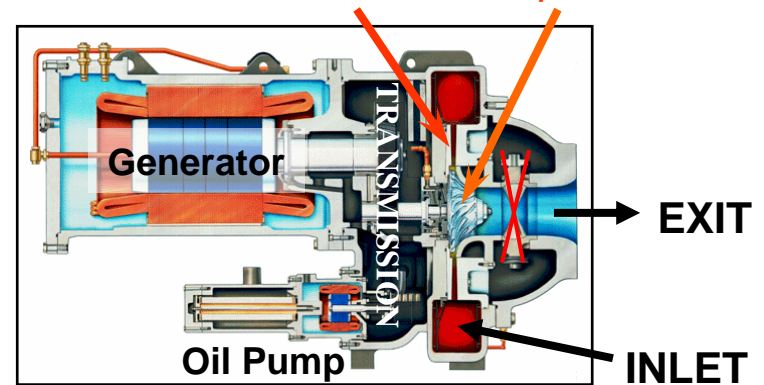


19 XR225 Centrifugal Compressor

## Organic Rankine Cycle (ORC)

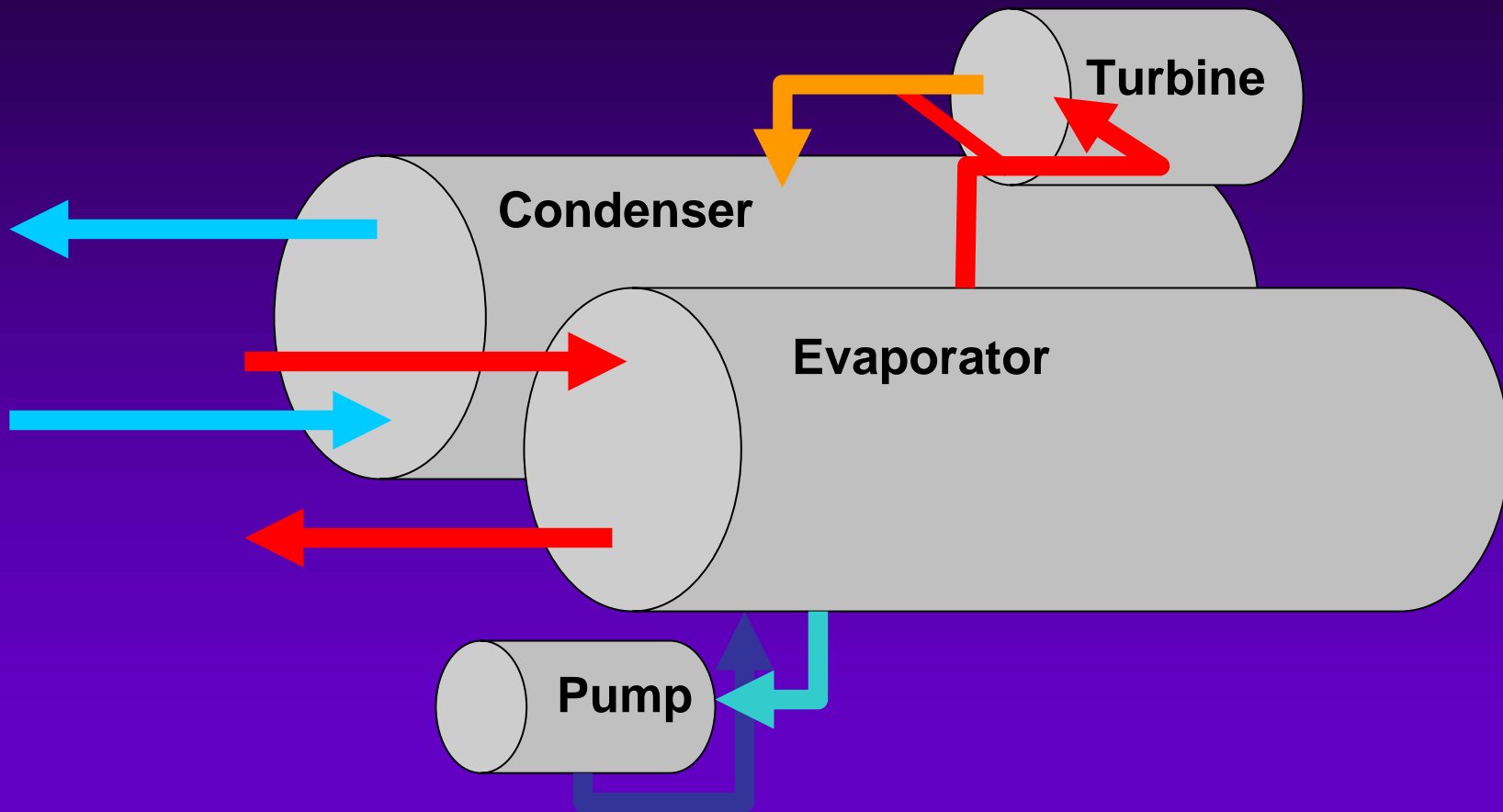


**Required Modifications**  
Nozzle Impeller



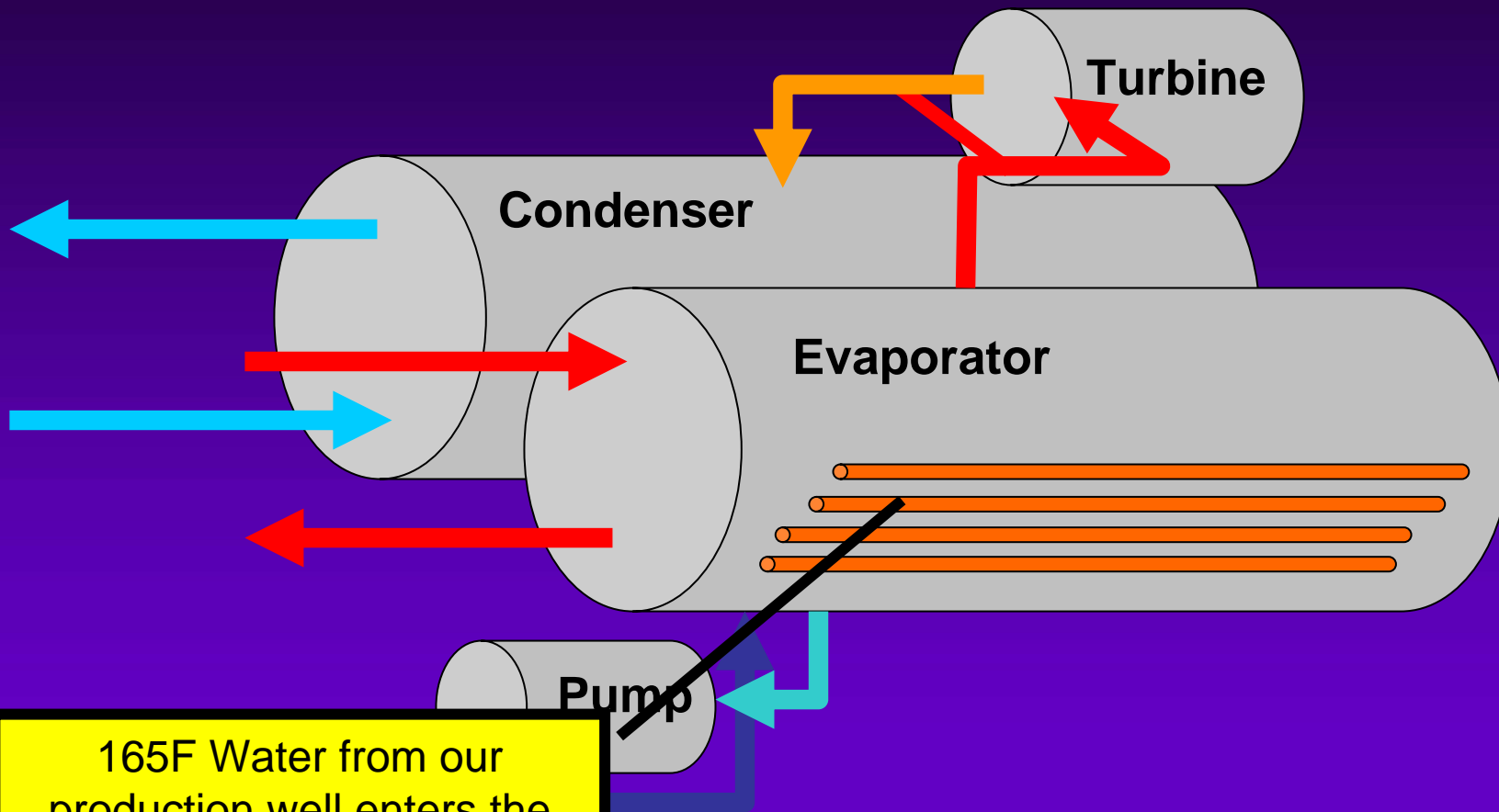
19 XR225 Radial Turbine

# Chena Power Plant



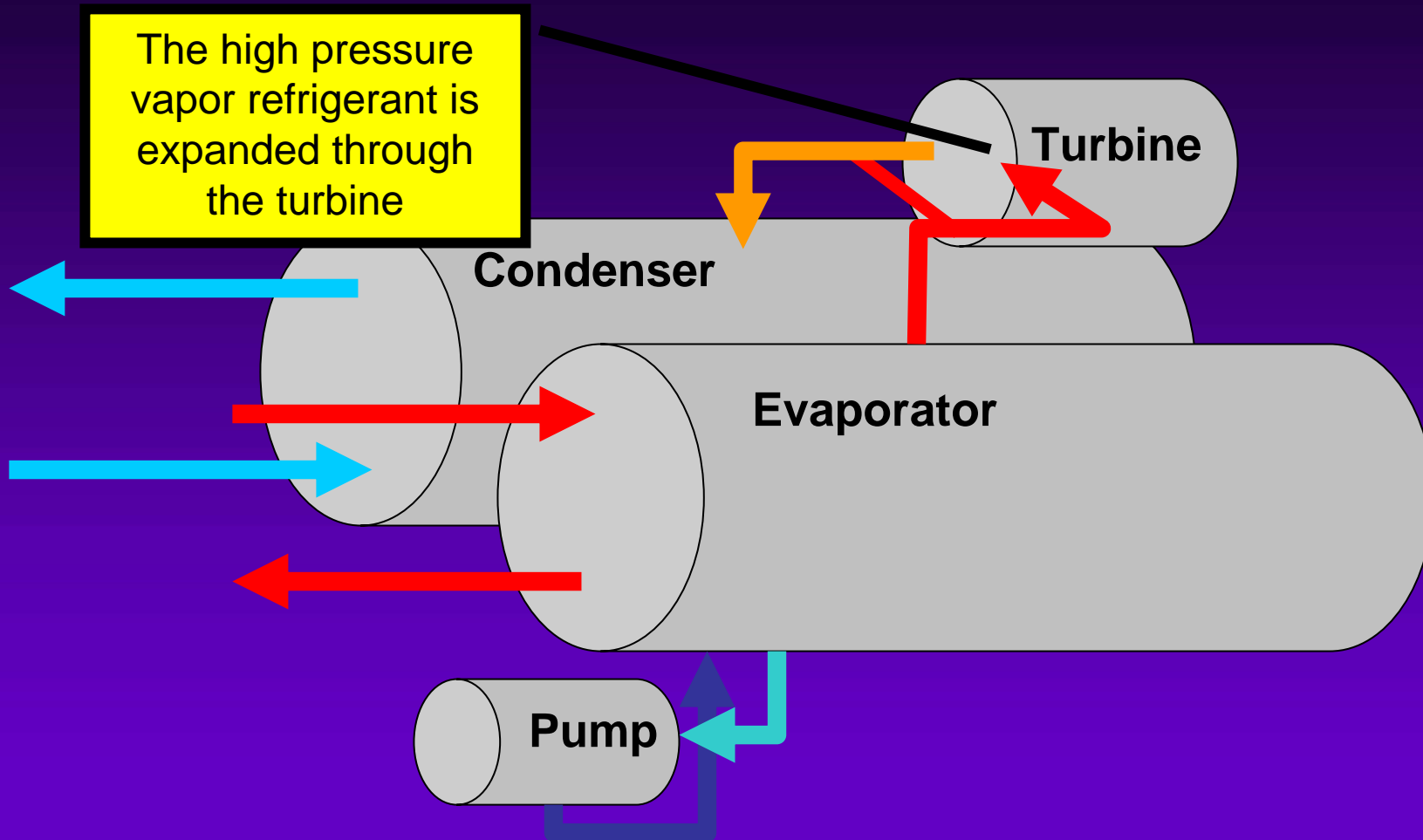


# Chena Power Plant

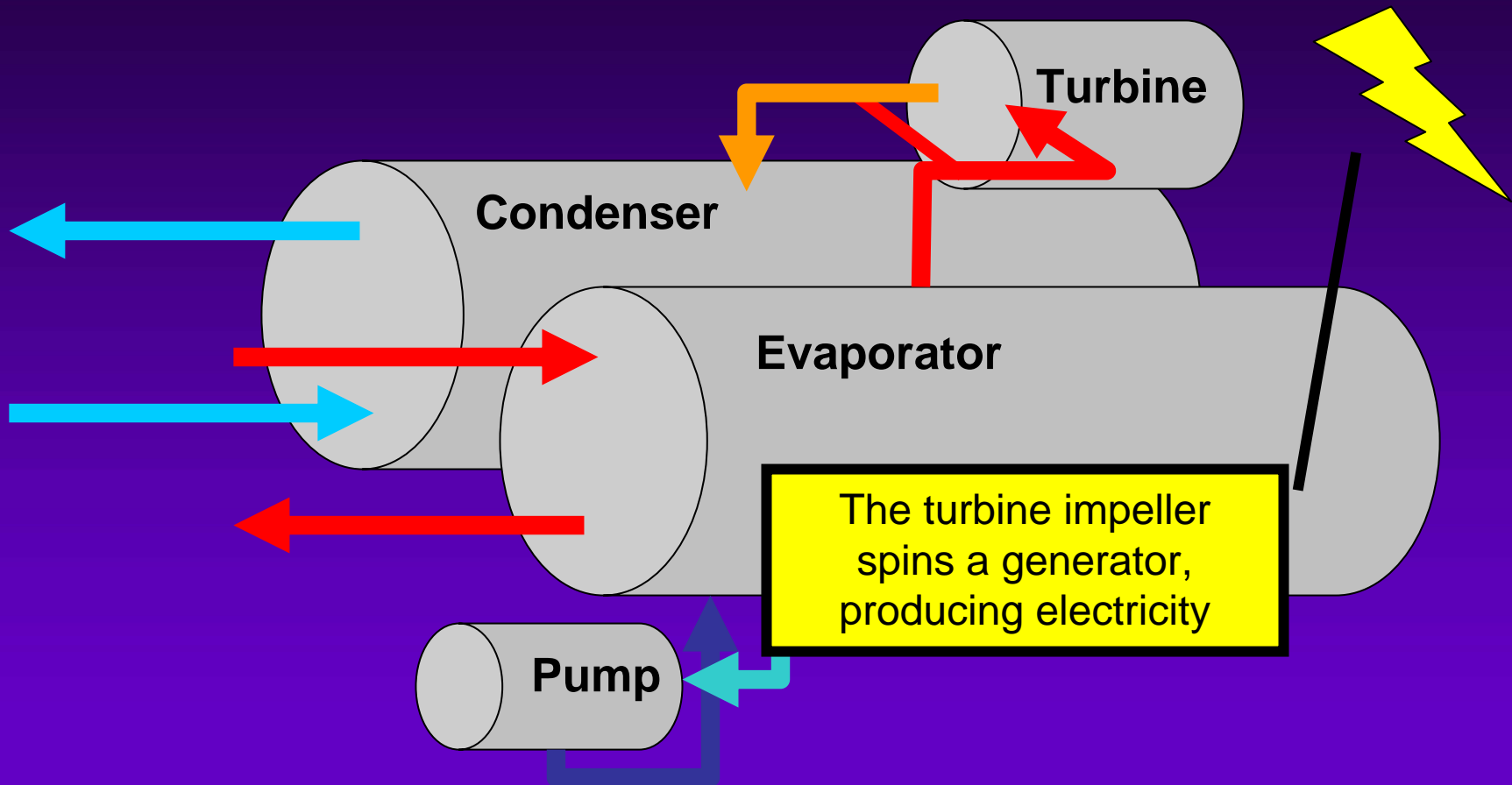


165F Water from our production well enters the evaporator and boils the refrigerant

# Chena Power Plant

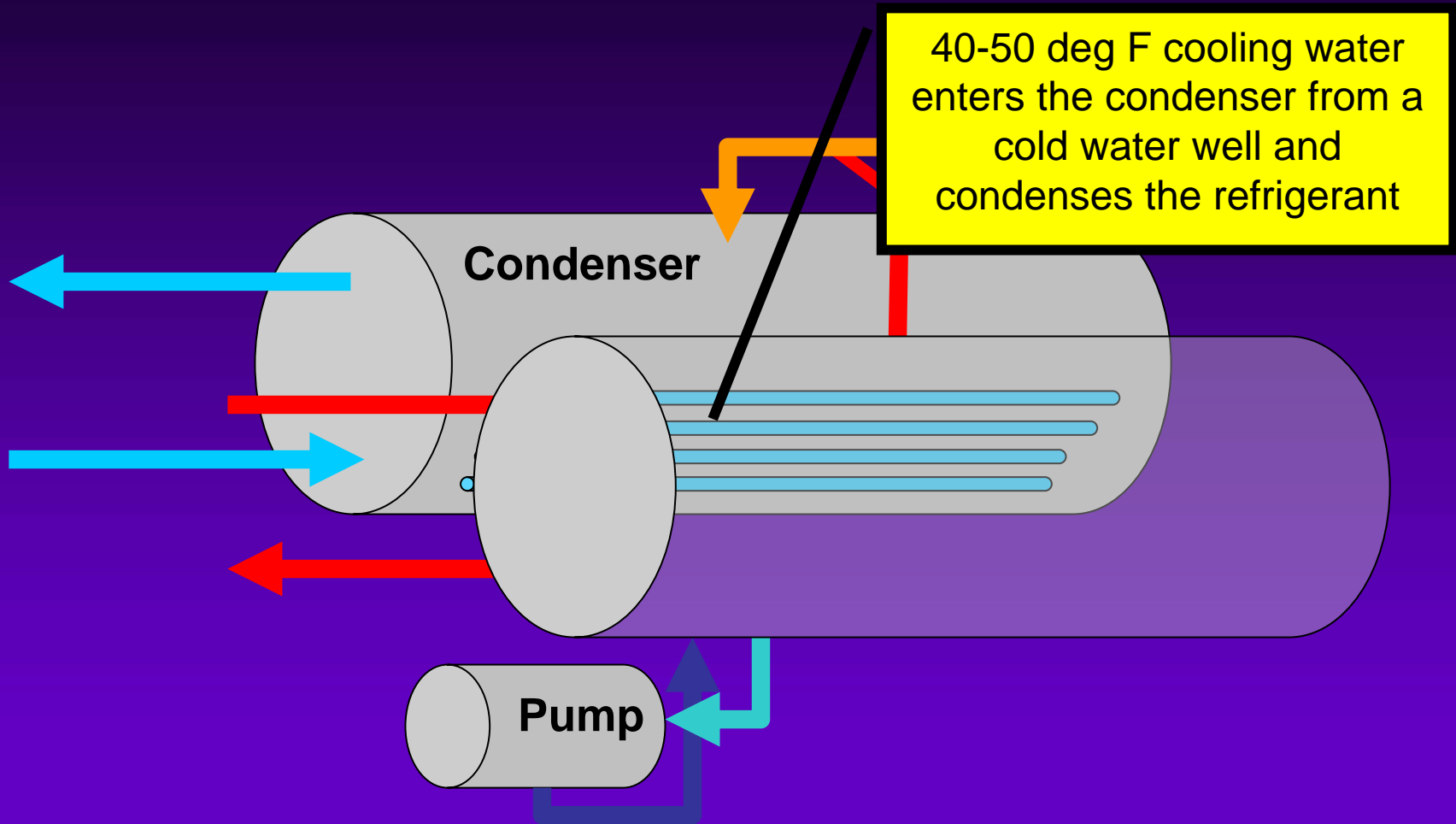


# Chena Power Plant



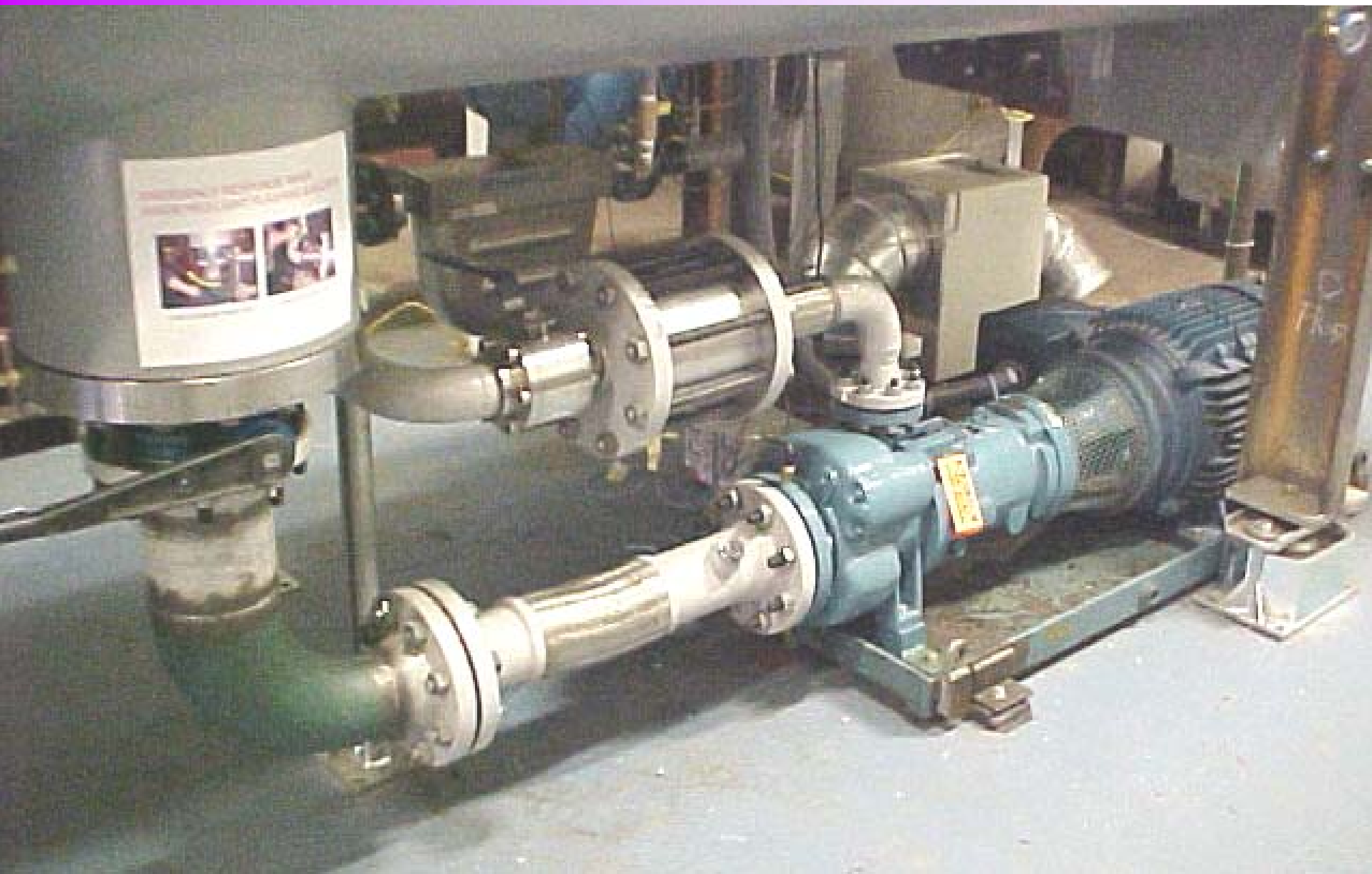


# Chena Power Plant





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Well #7  
500gpm, 165F



3000ft

Water Discharged to  
Monument Creek

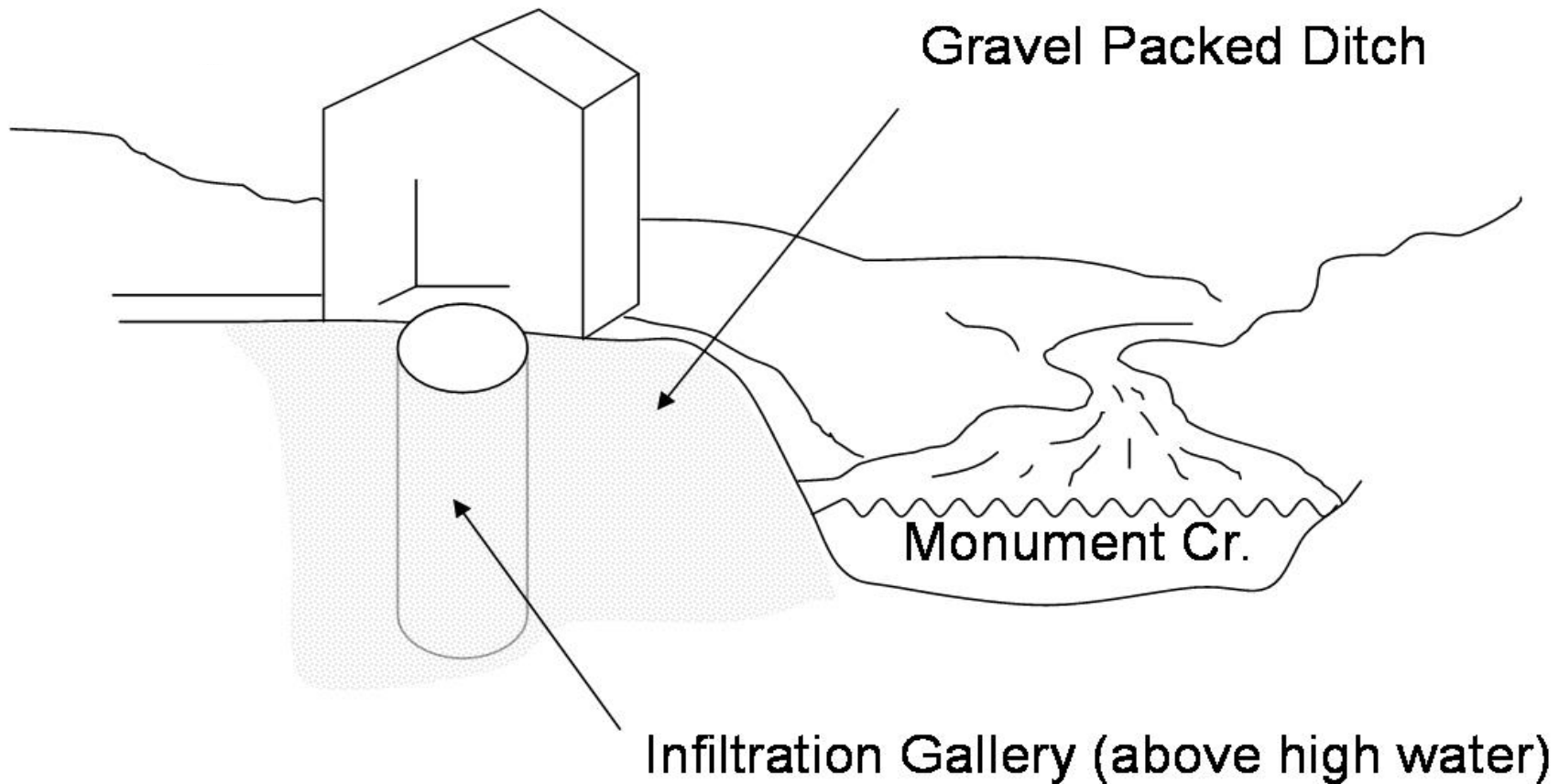


2700ft, 1500gpm



# Cold Water Supply

## Chena Hot Springs Cooling water Infiltration Gallery





# *Cold Water Supply*





# August 20<sup>th</sup> Official Opening – Chena Geothermal Power Plant



# *Project Awards and Recognition*



**2006 Green Power Leadership Award (EPA and DOE)**



**Project of the Year  
Renewable Energy Category  
Power Engineering Magazine  
PowerGen Conference 2006**

**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)**

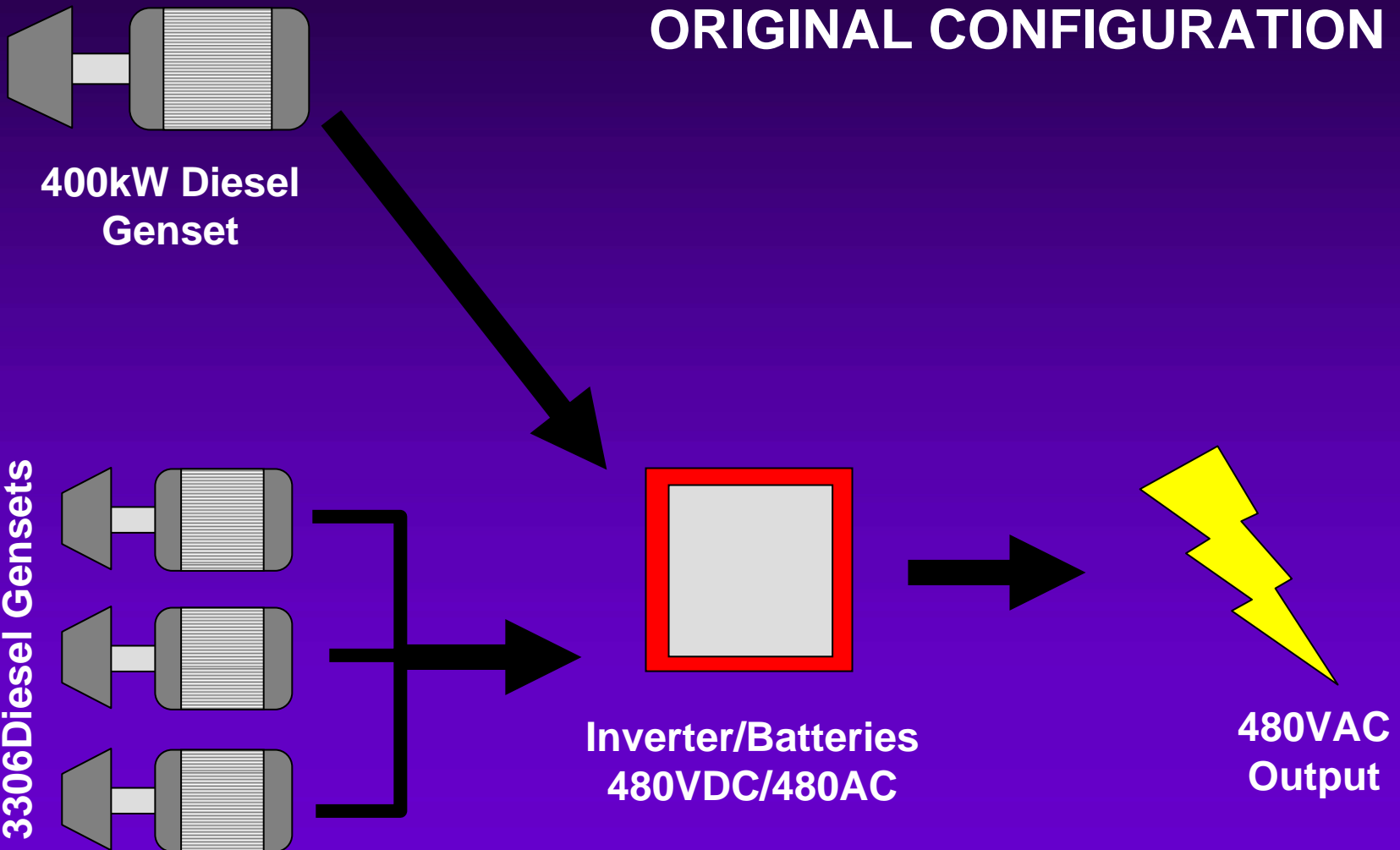


**Batteries 3MW Total**

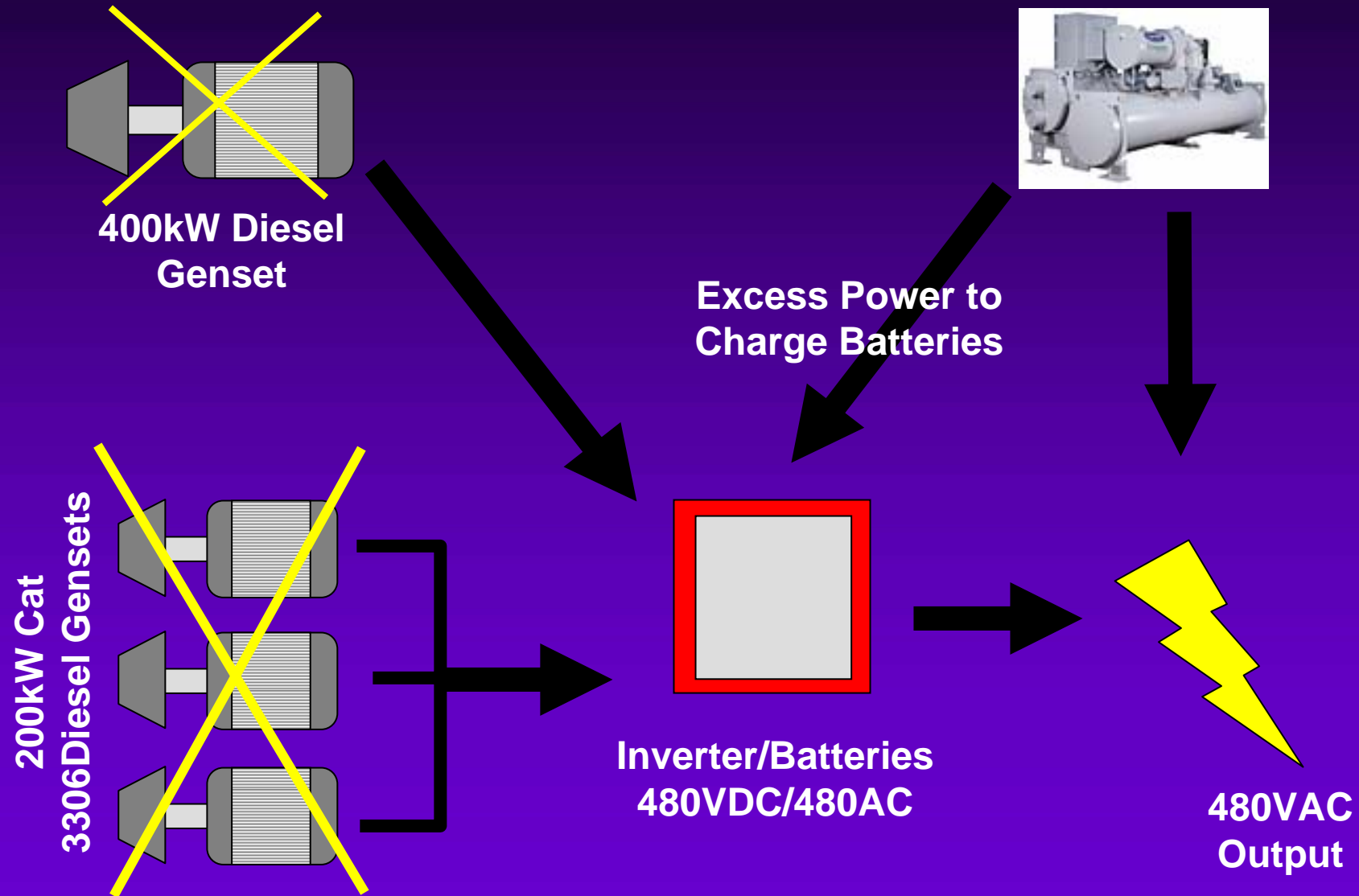


# Battery and UPS System

## ORIGINAL CONFIGURATION



# Battery and UPS System



# ***Project Expenses***



- 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



# *Project Economics*



- Offset \$160,000 of diesel fuel in 4 months of operation in 2006
- Has created 3 new skilled positions
- Has increased electric use onsite by 40% in the last Quarter of 2006
- Has operated with 95% availability

# Project Challenges

**Minor refrigerant leak in flex tube installed in bypass line (repaired in 36 hours)**



# Project Challenges

**Some freezeup and low  
water table problems during  
winter months with water  
cooled system**



# Project Challenges

**Installation of air cooled  
condenser eliminated  
freeze up problems**

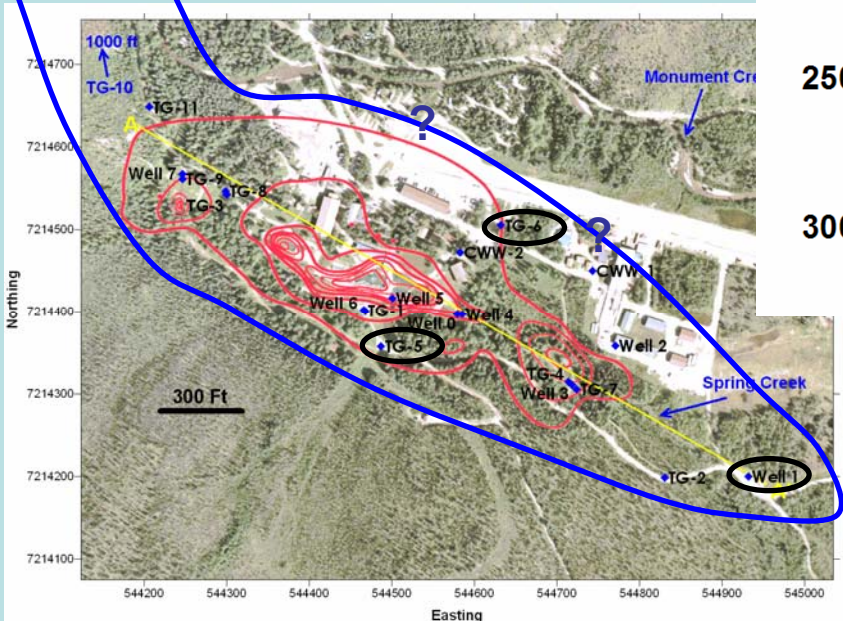
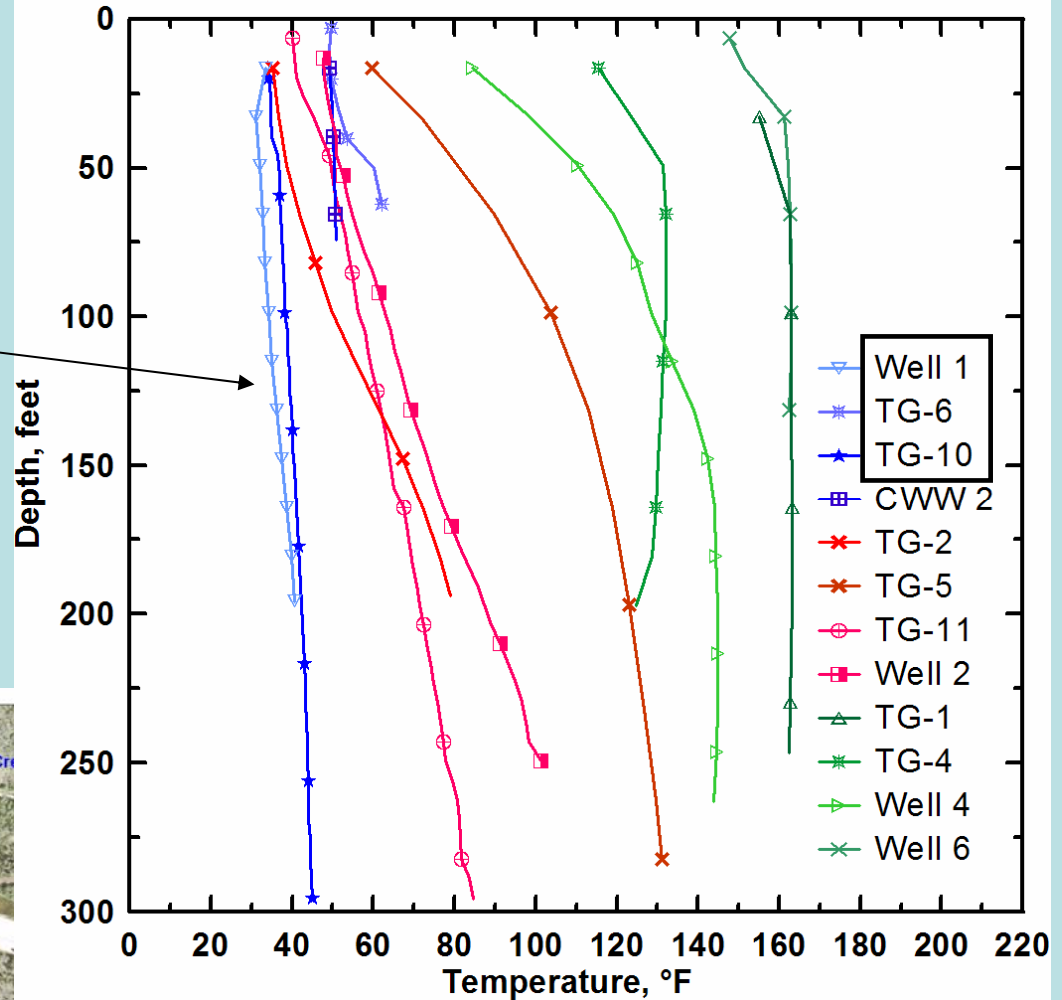




# Continuous reservoir monitoring program implemented

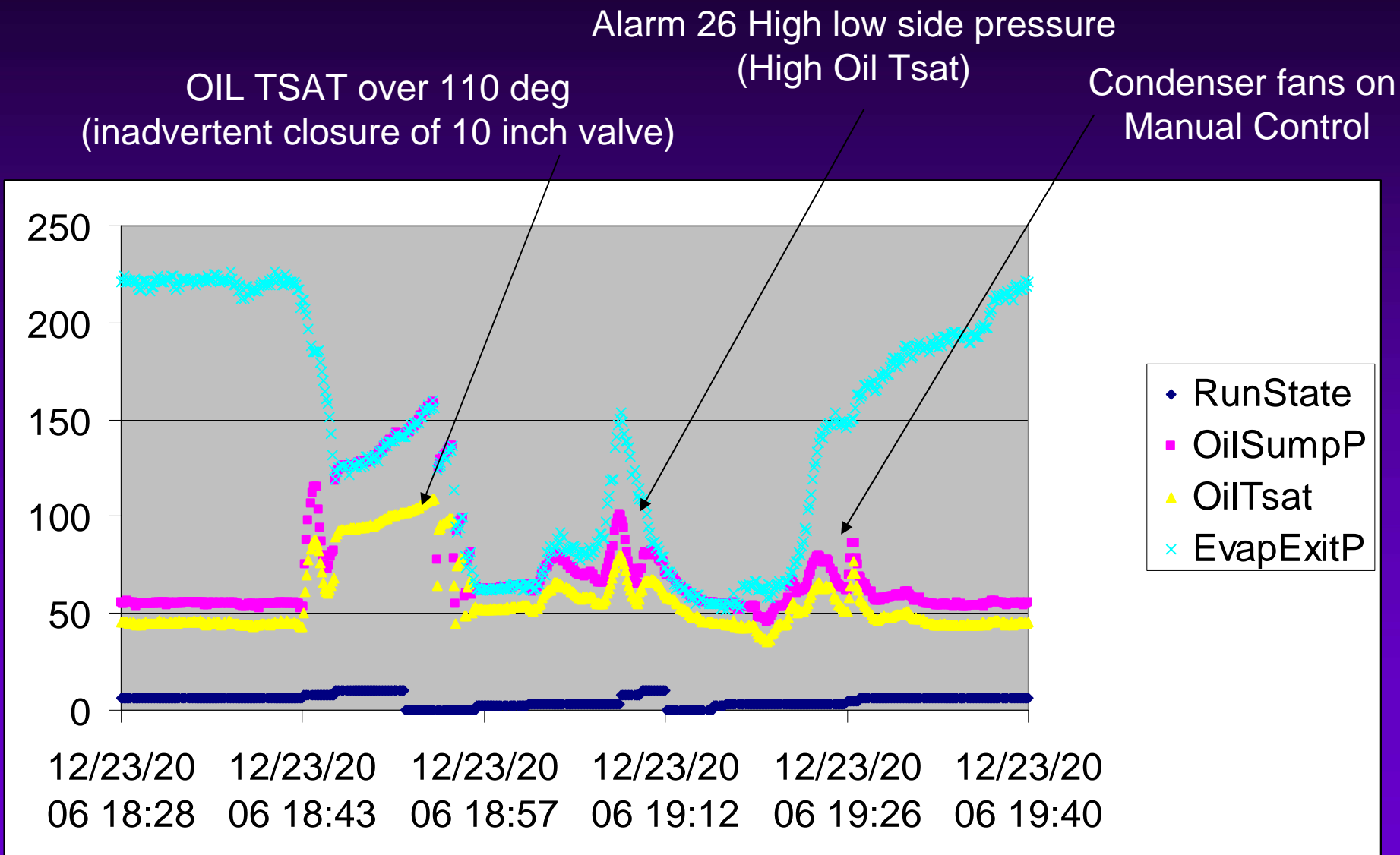
“Remote” wells (blue tones)

boundary of deep anomaly with current drilling

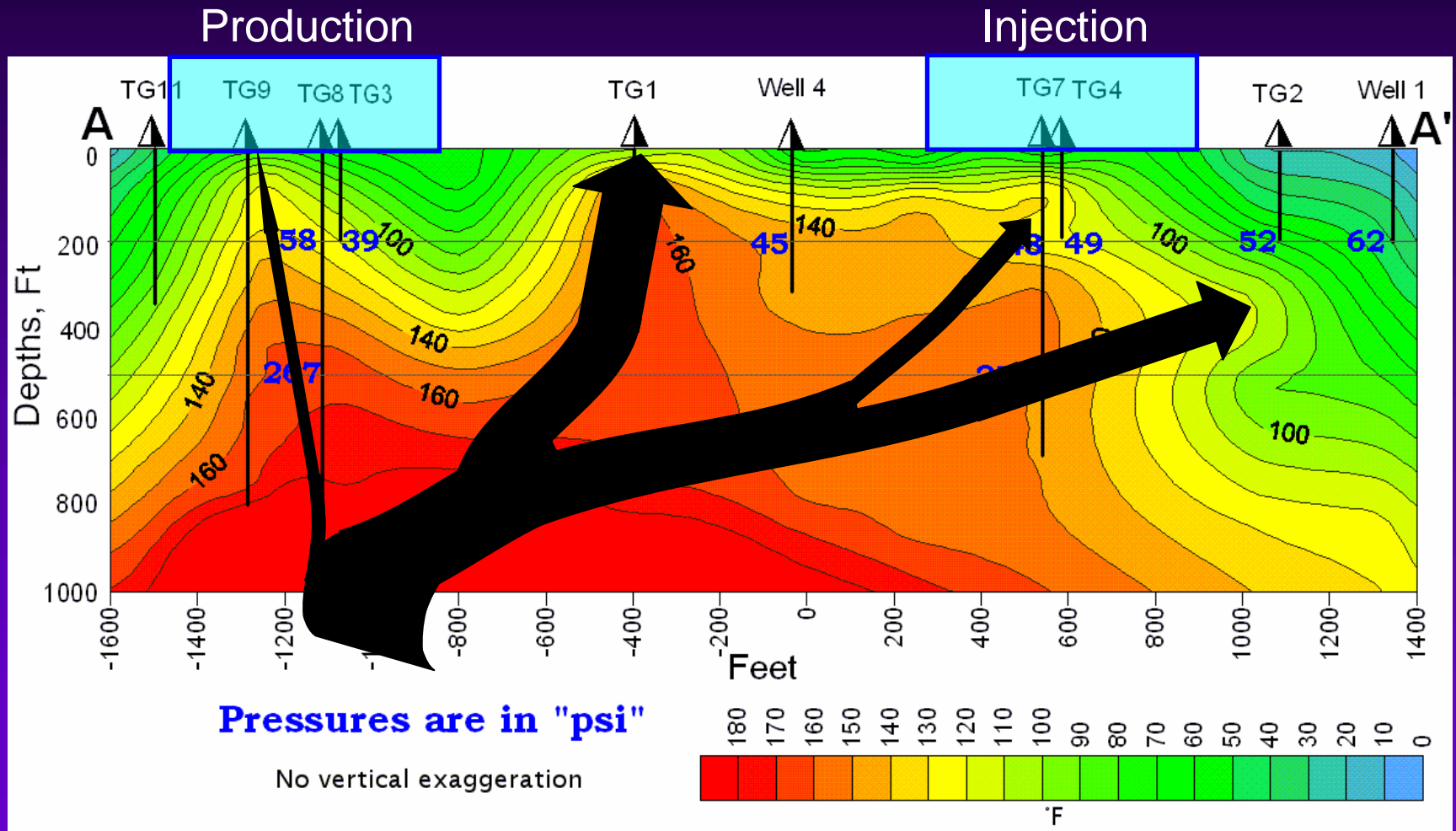


Lowest temperature gradients are 2-3 times the regional background.

# Project Challenges



# Project Challenges



# Chena Geothermal Power Plant

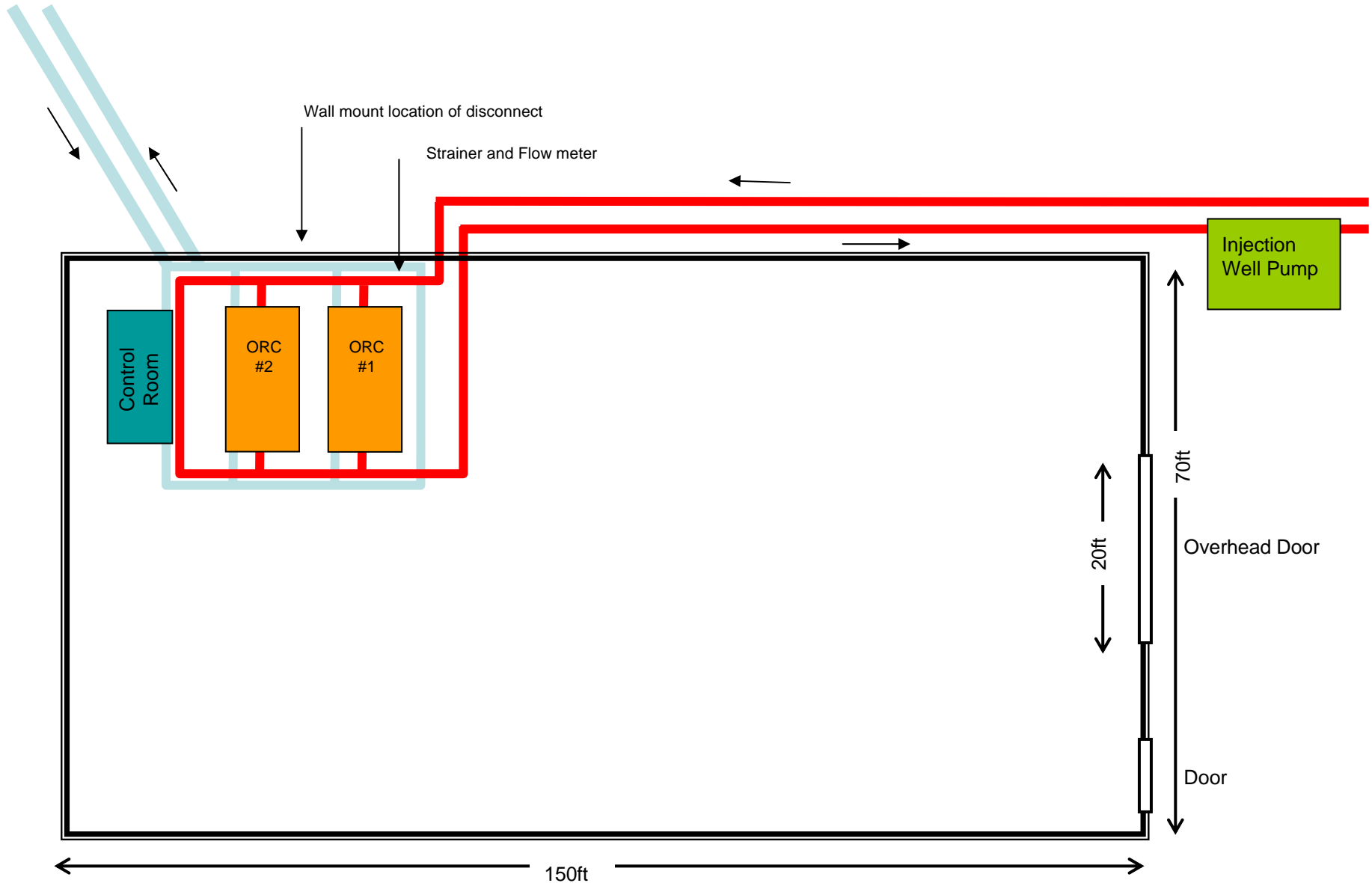




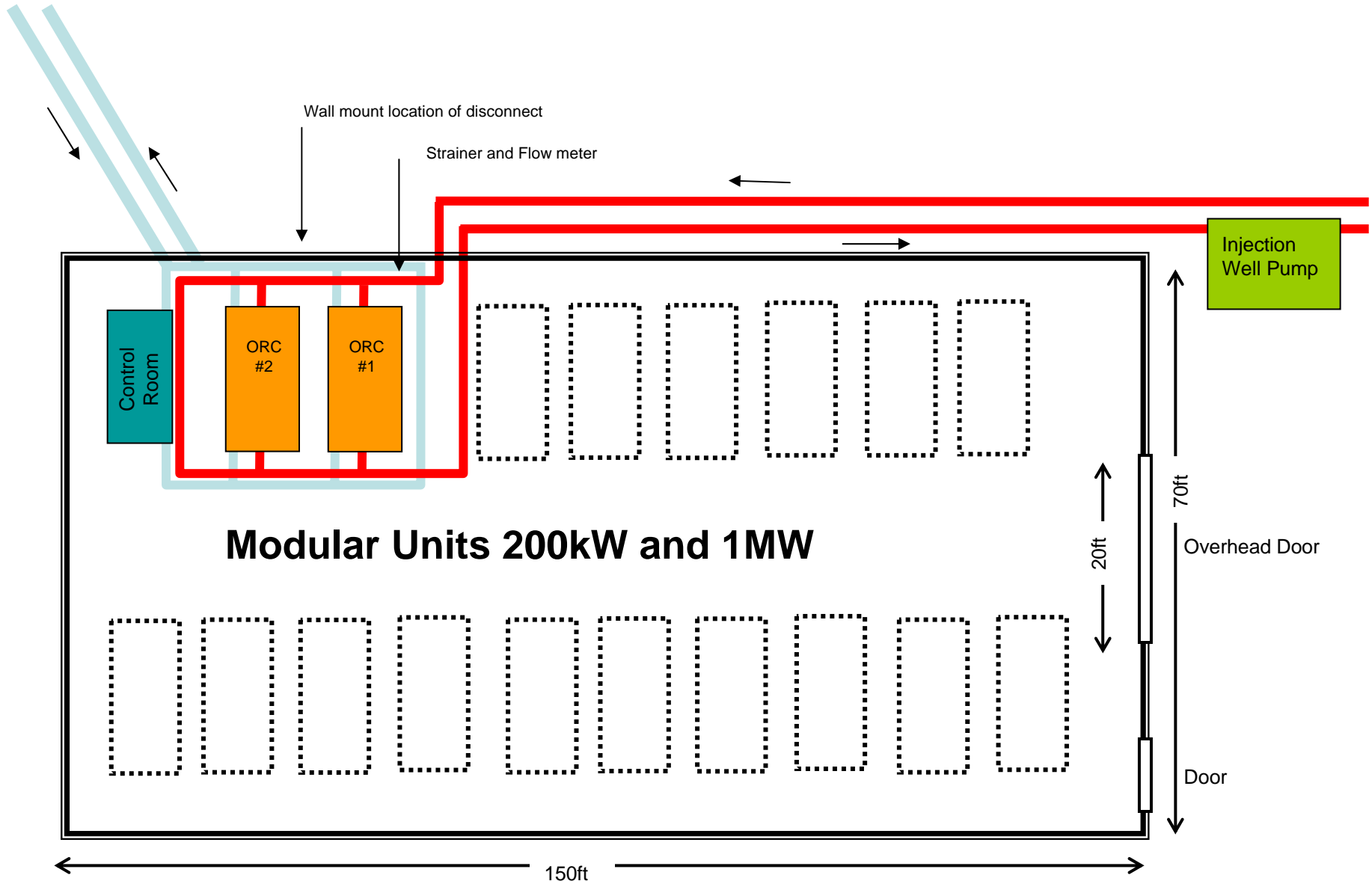
# Chena Geothermal Power Plant



# Chena Power Plant - Current

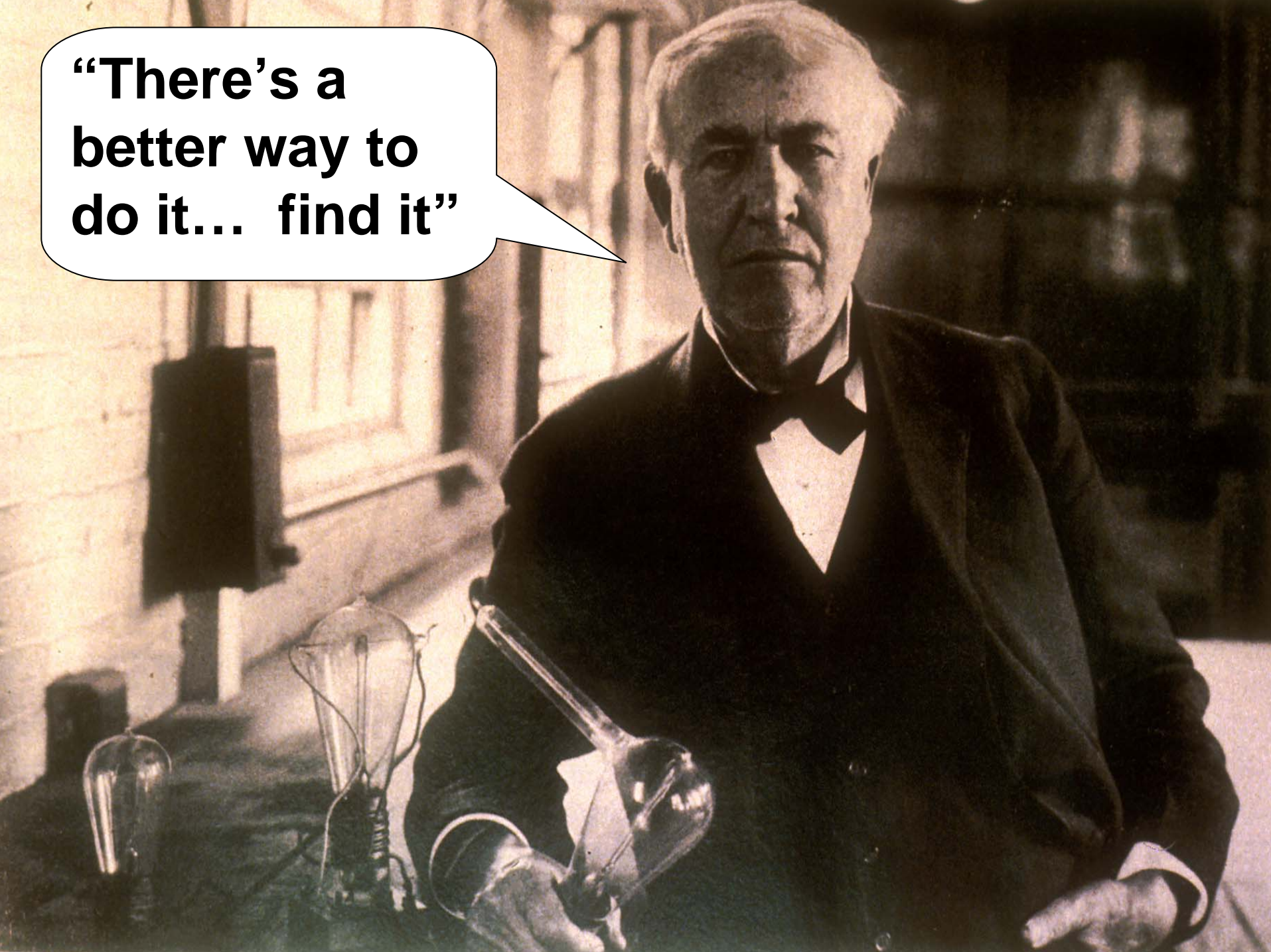


# Chena Power Plant - Future





**“There’s a  
better way to  
do it... find it”**







## **CHENA HOT SPRINGS RESORT**

***[www.chenahotsprings.com](http://www.chenahotsprings.com)***

**Mile 56 Chena Hot Springs Rd, Fairbanks, AK**

**(907) 451-8104**

## **Bernie Karl**

**Proprietor, Chena Hot Springs Resort**

***[recycle@polarnet.com](mailto:recycle@polarnet.com)***

***[www.yourownpower.com](http://www.yourownpower.com)***

**(907) 451-8104**