From Hot Water to Hydrogen

Bringing Geothermal Power to 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

- Electricity: 41%
- Transportation: 31%
- Refrigeration: 10%
- Supplemental Heating: 15%
- Baseload Heating: 3%
1st Aurora Ice ‘Hotel’ completed in January, 2004 ...
Voted as a dumbest business idea of 2004 by Forbes Magazine

I had a frozen asset, and I turned it into a liquid asset

Bernie Karl
Aurora Ice Museum rebuilt in January, 2005 ... And still standing ...
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)
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.
The hot water heats an ammonia and water solution in the ‘Generator’. The temperature is raised to the boiling point of ammonia.
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.
Cooling water from Monument Creek enters the Condenser and causes the ammonia vapor to condense back into a liquid at high pressure.
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.
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.
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.
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

- Absorption Chiller: 25 kW
- 200T V.C. System: 103 kW
- 50T V.C. System: 47 kW
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District Heating

- First geothermal well drilled in March 1998
District Heating

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- 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, 20,000ft² 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

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- 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
Alaska’s Geothermal Resources

Maps showing geothermal resources in Alaska, including bathymetry, bathymetric grid, heat flow, and geothermal area wells.

SMU Geothermal Map of Alaska, 2004

CHENA HOT SPRINGS RESORT
Alaska
Manley Hot Springs, Alaska  T = 140F,  T(res) = 210F
Circle Hot Springs, Alaska  $T = 140^\circ F$  $T(\text{res}) = 284^\circ F$
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.
Binary Cycle Power Plant

- **Turbine**
- **Generator**
- **Heat Exchanger**
- **R134a Refrigerant**
- **Reinjected Geothermal Water**
- **Geothermal Water (from production well)**
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:

\[ T \geq 165^\circ F \]
UTC divisions span many markets and industries...
Collaboration between divisions leads to the formation of UTC Power and the development of their CHP product line
Carrier Chiller

Refrigeration Cycle
Carrier Turbine Generator

Vapor Compression Cycle (VCC)

19 XR225 Centrifugal Compressor

Organic Rankine Cycle (ORC)

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
165F Water from our production well enters the evaporator and boils the refrigerant.
The high pressure vapor refrigerant is expanded through the turbine.
The turbine impeller spins a generator, producing electricity.
40-50 deg F cooling water enters the condenser from a cold water well and condenses the refrigerant.
The 25lbms/sec of liquid refrigerant is pumped back into the evaporator at high pressure.
Chena Power Plant
Chena Power Plant
Chena Power Plant

First Geothermal Power Plant in Alaska
Chena Power Plant

Only new Geothermal Power Plant in US this year
Chena Power Plant

 Lowest temperature resource used for power generation in the world
Chena Power Plant

Well #7
500 gpm, 165°F

Water Discharged to Monument Creek

3000 ft

2700 ft, 1500 gpm
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

ORIGINAL CONFIGURATION

400kW Diesel Genset

200kW Cat 3306 Diesel Gensets

Inverter/Batteries 480VDC/480AC

480VAC Output
Battery and UPS System

400kW Diesel Genset

200kW Cat 3306 Diesel Gensets

Excess Power to Charge Batteries

Inverter/Batteries 480VDC/480VAC

480VAC Output
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

Temperature (F)

Depth (feet)
Daily Tours
Water Power
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
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 ...

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Alaska
Alternative Fuels

Alternative Fuels – Used Vegetable Oil

THE FUTURE BEGINS TODAY...
at Chena Hot Springs Resort
YOU ARE FOLLOWING A VEHICLE
POWERED BY WASTE VEGETABLE OIL
www.yourownpower.com
Hydrogen

10kW Electrolyzer
200kW Biomass System

ORC Biomass Power Plant

- Power output

- Med temp ORC

- High temp ORC

- Thermal Oil Heater

- Air Cooler

- District Heating Loop
Wood – the old standby

Northern Commercial woodpile in Fairbanks

Photo Credit: UAF Archives
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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