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An Example of Small Scale Geothermal Energy Sustainability: Chena Hot Springs, Alaska

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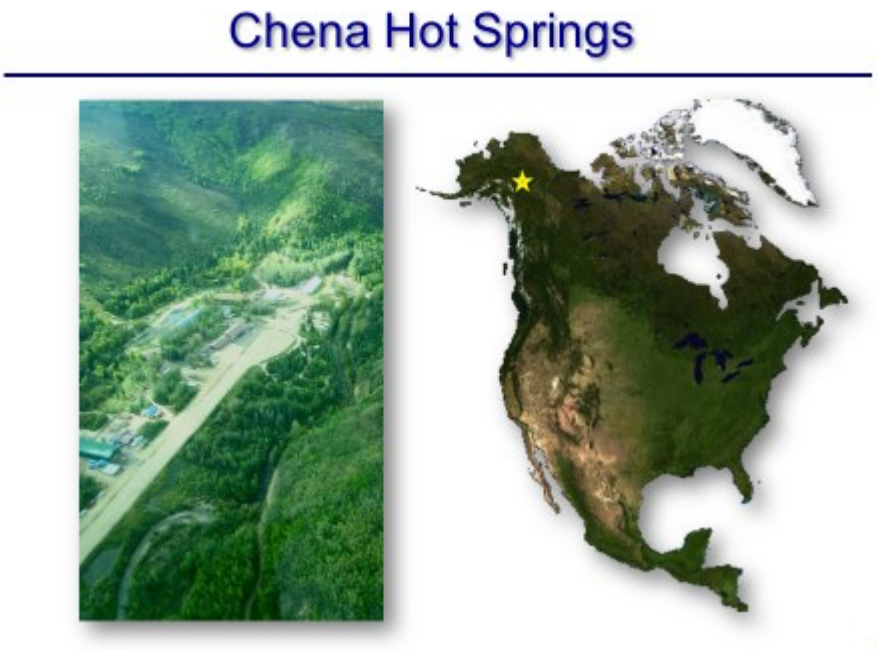
ABSTRACT

Chena Hot Springs near Fairbanks Alaska has been a leader in the development and use of geothermal energy. The hot springs were discovered in 1904 by the US Geologic Survey and used by miners to relieve their aches and pains with the "healing waters".

Bernie and Connie Karl purchased the property in 1998 and since then have transformed the hot springs into a sustainable resort with a 400 KWe geothermal generating facility that replace diesel generators. All the buildings at the resort are heated with the geothermal water. Two greenhouses supply vegetables to the restaurant and an ice museum is cooled with the geothermal resource. After extracting the heat, the geothermal fluid is injected back into the thermal reservoir to be re-heated by the earth. Being green, renewable, and sustainable is a major goal for the owners operating the resort.

1. INTRODUCTION

Chena Hot Springs, Alaska has a long and colorful history. It was first noticed in 1904 by a US Geological Survey crew and actually located the next year by Robert Swan, a Swedish gold miner, who was desperate for relief from pain of rheumatism and found relief from the healing waters of Chena.



The springs were developed and primarily used by miners and some adventuresome Fairbanks residents who traveled up to three weeks to reach Chena. As travel conditions improved, the springs became more popular; however, business was not sufficient to survive and the State of Alaska assumed the location. Little effort was expended during this time and eventually the facility went up for sale. In 1998, Bernie

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and Connie Karl bought the healing waters and through their energy and the energy from the geothermal resource the future began to happen.

2. DISCUSSION

The new owners saw the great potential of geothermal energy, especially in their locale near the Arctic Circle where some of the world's coldest temperatures are recorded. They worked diligently to capture the heat from the geothermal resource which had previously been used only for the spa. The buildings, that traditionally used fossil fuel, were first and then a greenhouse was built to raise lettuce, tomatoes, and herbs for use in the resort restaurant. The geothermal resource is presently producing power, heating resort buildings and a greenhouse, and providing healing waters to a large spa.

Ironically, it is also used to cool an ice museum, keeping the inside temperature for the ice sculptures at a constant -4°C throughout the year, even when summer temperatures rise to the +32°C range.

This Auora Ice Museum contains ice sculptures carved by Steve and Heather Brice, world champion resident ice masters. A two stage ammonia adsorption chiller designed by Energy Concepts Company keeps the museum at its constant temperature utilizing the Chena geothermal resource.

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The buildings benefiting from the geothermal water for heating are the Moose Lodge, which is a signature single room and family suite building; an activititorium for large events at the resort (a name conceived by Connie); restaurant; curio store; Artic Celebration dining rooms; several special meetings rooms; staff dorms; and the office complex. The total square footage conditioned is approximately 10,000 square meters.

The greenhouse is a 656 meter square structure which maintains a constant inside temperature of 24°C year around with geothermal water even when the outside temperature drops to -46°C. Expansion of the greenhouse has been initiated to grow Alaska Grown (which is trademarked) Chena fresh lettuce for sale

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to the public in the Fairbanks, Alaska area.

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The geothermal water, dubbed “Healing Waters” by the Alaskan natives, is also used directly by feeding into two pools, one a large outdoor natural Rock Lake and the other a smaller indoor pool. Hot tubs for soaking are also available. These waters require a cooling stream in order to be comfortable for bathing use.

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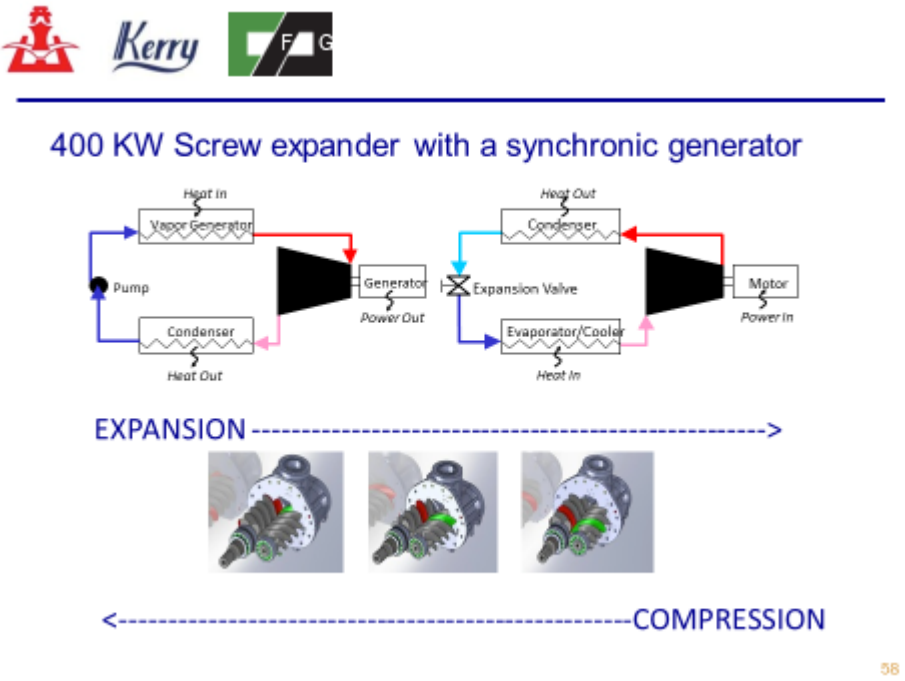
Bernie and Connie's big dream was to generate electrical power using geothermal water to replace the large diesel generators that powered the facility. Taking advantage of new binary technology developed by United Technology, Bernie demonstrated the effective use of low temperature geothermal fluids to produce power. Through this early demonstration of low temperature geothermal power generation, Chena Power was nominated and received several technology awards.

The binary plant utilizes R134a, a fluid to flash to a vapor, which then drives the turbine to produce electricity. The binary system at Chena involves several steps. First the 74°C geothermal fluid enters the evaporator which is a large heat exchange. Here the hot geothermal fluid transfers its energy to the R134a fluid converting it to a gas. The R134a gas is then routed to the turbine which is connected to a generator to produce electricity. After passing through the turbine, the gas is routed to a condenser where natural cold water (2.8 to 7.2°C) is used to convert the R134a gas back to a liquid. In both the evaporator and the condenser, the R134a fluid is not in direct contact or mixed with the geothermal water or the cold water so the working fluid remains pure. The geothermal water is then routed through the buildings before being re-injected back into the thermal reservoir. The 400 KWe binary system produces 100% of the electric power needed by the Chena Hot Springs Resort. Because the system is a closed loop, nothing is emitted to the atmosphere. The power unit at Chena utilizes geothermal fluids at 74°C to produce the 400 KWe of power for the Resort, the lowest geothermal temperature producing power in the world.

3. PROPOSED EXPANSIONS
Chena is not sitting still. Recent deeper drilling has reached higher temperatures and flows which allow for greater application such as supplying geothermal power to neighbors near Chena in a distributed energy concept. A new development in turbine design utilizing a screw expander concept to increase the efficiency of the binary units is being considered. Chena Power LLC and Kaishon Industries LLC have developed an organic Rankine cycle, direct drive synchronous screw expander utilizing the lower temperature geothermal resource at Chena Hot Springs to generate electrical power.



The screw expander concept utilizing lower temperature geothermal resources will provide power units at a lower cost, be more reliable, and commercially viable for use in stand-alone grid power systems. The units do not require hydro carbon fueled generation as an inducer for plant start-up. The ORC synchronous screw expander generation system operates at 80°C and spins at 1800 rpm providing stand-alone power for small to intermediate demands. Units are being developed at sizes ranging from 2.5 KW to 2 MW which would be ideal for applications varying from individual private use to small village power in remote areas not served by large power grids.

The goal at Chena Hot Springs to become sustainable with geothermal energy has won the resort several awards. In 2006, the US Department of Energy and US Environmental Agency awarded the Green Power Leadership Award. The same year, Power Engineering Magazine awarded Chena the Project of the Year Award. In 2007, the US Department of Energy and the R and D Magazine awarded Chena the Research and Development 100 Award. The National Science Foundation Award for Small Business Innovation was also bestowed on the Resort in 2007. Chena received awards in 2008 for demonstration of the UTC ORC Power Plant with geothermal water from oil and gas wells. In 2013 Bernie and Connie Karl received a Special Recognition Award from the Geothermal Resource Council for their work in promoting and developing geothermal resources in Alaska.

4. SUMMARY

The geothermal activities at Chena Hot Springs Alaska are an example of what can be done with low temperature geothermal resources in a remote area. This example of power production, space heating and cooling, greenhouse operations, and self-sustainability could be repeated in many places throughout the world. Bernie lives by: “Achieving sustainability through energy and food independence today to build a strong tomorrow.”

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Photographs courtesy Chena Hot Springs and Chena Power, (2014).