Adventures in the Life of a Small Geothermal District Heating Project Or (The Little Project That Could) Part II

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ABSTRACT

A small community drilled a 2100 foot geothermal well to use the geothermal water for district heating. Pump test results showed a long term production rate of 37 gpm at approximately 190°F with a pump set at 237 feet.

A district heating system has been developed around that resource to provide space heating and domestic hot water to 34 existing buildings totaling about 53,000 square feet. Geothermal effluent is discharged to surface waters of a river after flowing through an granulated activated carbon (GAC) filter to remove mercury. The project will offset about $30,000 per year in propane and electric costs after carbon filter replacement and related discharge costs.

This paper describes the conclusion of a five-year struggle of a small community and their funding agencies to fund, permit, and install the geothermal district heating system. This paper covers the final stages of environmental permitting, system design, installation, and system performance.

Private, state and federal partnerships can yield great benefits to small communities willing to develop geothermal resources.

Introduction

Canby, a small town in Modoc County, California, shares many similarities to other places in the Western United States. It is high and dry being 4300 feet above sea level and has about 12 inches per year annual rainfall. It is predominately rural with most of the land being used for grazing livestock and growing different kinds of hay. Major employers in these areas tend to be state and federal agencies that manage public lands. Private businesses exist to serve the needs of the farmers, ranchers, government employees, and travelers on their way to someplace else.

Winters in Canby include cold, snow, and significant heating costs.

But Canby, like many other small western towns, has abundant geothermal resources. I'SOT Inc. decided to take the plunge and develop the geothermal resource to reduce significant heating costs and to provide a measure of energy independence.

The project also had the engineering challenge of meeting the community heating requirements with the limited resource, and the more significant challenge of satisfying the regulatory requirements for construction and operation.

In Part I of this paper, I'SOT Inc. had:

- Obtained grants from the Idaho Operations Office, Department of Energy (DOE) and California Energy Commission (CEC) to drill a geothermal well and install a district heating system.
- Verified, through the expertise of the OIT Geo-Heat Center (GHC) that a viable geothermal resource was the result of DOE assisted drilling.
- Discovered concentrations of arsenic and mercury in the geothermal effluent that were above maximum contaminant levels (MCL) for discharge to land or surface waters.
- Discovered that mercury in the geothermal effluent could be treated with activated carbon in laboratory testing.
- Struggled but succeeded in obtaining a National Pollutant Discharge Elimination System (NPDES) discharge permit for discharge of geothermal effluent to the Pit River.
- Successfully negotiated a California Environmental Quality Act (CEQA) review for project construction.
- Entered into a Phase I subcontract with the National Renewable Energy Laboratory (NREL) to permit and engineer the project; a Phase II subcontract was on hold until subsequent environmental review was completed.

Let the Games Continue…

The project NPDES permit was obtained on April 29, 2002 enabling I'SOT to invoice the California Energy Commission (CEC) for the entire grant funding amount of $304,525 (minus 10% retention). I'SOT had already met the 50% project match obligation during drilling operations, so the CEC agreed to expend grant funding after obtaining the discharge permit.

Unfortunately, California became involved in another budget standoff in the state legislature and the CEC didn't have time enough to process the invoice for project materials. The "budget crisis" ended in September 2002 and the CEC dispersed funding for materials-only in October 2002, just in time for poor weather conditions. At the same time, the six month waiting period set the stage for further NREL participation and an opportunity to have installation expenses covered through a Phase II subcontract.

At the September 2002 Geothermal Resource Council (GRC) annual meeting in Reno, I'SOT, Inc., the CEC and NREL agreed to partner toward project completion. During this time, NREL initiated their environmental review through the National Environmental Policy Act (NEPA), to determine whether they could expend funding for project installation, even though environmental work had been done previously under a CEQA review. This author was now in for a real education in environmental procedure and politics.

Environmental Reviews, the Sequel

The initial CEQA review culminated with a Mitigated Negative Declaration by the lead agency, the Modoc County Planning Department. They concluded that the project could go forward as long as a plan had been implemented between I'SOT, Central Valley Regional Water Quality Control Board (CVRWQCB), USFWS, and the California Department of Fish and Game (DFG) to address water quality and wildlife issues. This minimized the Planning Department's regulatory involvement.

However, when NREL, a DOE laboratory, looked into funding the project, the work done on the CEQA document began to look limited in it's scope. Federal involvement now brought a "nexus" to the project that forced the USFWS to address biological issues in a more comprehensive way.

On September 10, 2002, the NREL NEPA environmental review began. An NREL site visit was conducted in Canby and was attended by I'SOT Inc.; NREL staff; MHA-Environmental Consulting, NREL/DOE consultant ; US Fish and Wildlife Service (USFWS); CVRWQCB; and the Pit River Tribal representatives with their consultant.

The USFWS conducted a survey of the Pit River that verified there were no endangered Modoc Suckers in the main stem of the river. All previous indications were that the sucker resided in cooler tributaries. They informally reasoned that even if the sucker was found in the river, the concentrations of mercury after discharge would have no measurable effect. They organized a detailed presentation during the river survey, at the proposed discharge point by the NREL environmental consultants (Figure 1).

Figure 1. NREL consultants and USFWS discuss I'SOT geothermal discharge to the Pit River with respect to endangered species.

Thus began a discussion of project issues that I'SOT thought had either been resolved or didn't even know existed.

In the *issues that I'SOT thought had been resolved column*, a 5200 foot discharge pipeline to the Pit River had been permitted by the Planning Department. However, 1,050 feet of the pipeline went through pasture that I'SOT had grazed cattle on for twenty years. Agencies look at land differently than property owners. One man's pasture is the US Army Corps of Engineers (USACOE) wetland. MHA's environmental work headed off problems with the Corps by addressing the issue. The discharge line was re-routed along a levee road; a much better plan. The CEQA document also had to be amended by the Modoc County Planning Department to reflect the routing change which took additional time and money.

Also, the Modoc Sucker and bald eagle addressed in the CEQA document, now had to be dealt with formally under a NEPA. This authorized the USFWS to prepare a biological opinion. Typically, regulatory agencies prefer to conduct informal consultation for projects with fewer impacts such as this to reduce their workload.

In *the issues that I'SOT didn't even know existed column*, the subject of mineral rights was raised and the idea of geothermal water being considered a mineral was new to I'SOT. The subject was never brought up by the California Department of Oil, Gas and Geothermal Resources (DOGGR) or the Idaho Office of DOE before drilling the exploration well. After several days in the Modoc County Recorder's office and a call to verify our findings with Bureau of Land Management (BLM), I'SOT could now claim that they owned mineral rights to the geothermal resource they had drilled three years earlier.

Another issue that I'SOT didn't know existed was the need for Native American consultation. I'SOT owned or their members controlled the property on which the project was to be constructed. There were no designated archeological sites on the main project site and the land had been used for fifty years as a lumber operation; the land had been severely disturbed. Further, I'SOT had a good relationship with the local Pit River Tribe, as many of their children over the past twenty years had come to the I'SOT Group Home as adolescents. Even though I'SOT didn't see a problem at the time, tribal emotions about the Four Mile Hill Geothermal Project at Medicine Lake spilled over to the I'SOT Project. To make matters worse, a tribal elder that had lived across from a local hot springs for many years died, leaving some tribal members to believe the man's passing was a premonition that the I'SOT Geothermal Project shouldn't go forward either. Because of mutual respect and a series of one-on-one meetings and phone calls in February and March 2003 with I'SOT, the tribe chose not to actively oppose the project.

However, when a Finding of No Significant Impact (FONSI) for the I'SOT Project was issued by the DOE on March 7, 2003, I'SOT could still not proceed with construction until the Pit River Tribe had determined their role in monitoring of trenching activities. Unfortunately, the tribe had stopped responding to communication from I'SOT.

If the Right One Doesn't Get You, the Left One Will

Working with two funding agencies can be a dream come true with respect to project financing. It can also be very challenging. The CEC and NREL had different paperwork requirements and expectations on when project construction should begin and end. The CEC had paid for 90% of project materials in October 2002 and, by all rights, expected substantial project completion by May 2003. The project would be assessed at that time by the CEC to determine whether the remaining 10% of the funding would be allocated to the project or lost; some funding has a limited shelf-life and non-compliant projects can lose out.

Work could not be started for NREL, on the other hand, until a Phase II subcontract was signed. That subcontract was dependant on the resolution of monitoring activities.

I'SOT did the best it could and hoped for the necessary flexibility from the agencies. On April 21, 2003, I'SOT signed a monitoring contract with a local archeological firm and proceeded with project construction. I'SOT placed the central plant slab and framed four walls (Figure 2). Approximately 1500 feet of discharge trenching was excavated and all piping for discharge and distribution piping was on site ready to be installed.

Figure 2. Beginnings of the I'SOT geothermal district heating central plant, May 5, 2003.

To make a bad situation worse, all this was happening while the wettest spring in recent memory was upon us. The Pit River had flooded the bottom land where discharge pipe trenching was to occur and working conditions were very poor. On May 5, 2003, the CEC conducted a site inspection. It must have looked bad for all the reasons I'SOT had for lack of project completion. I'SOT very much needed CEC support. The CEC soon released remaining project funding and I'SOT signed a subcontract with NREL on May 12, 2003 to complete the project. Soon afterward, project construction accelerated due to improved weather conditions.

Now the Fun Part…

With all permitting, monitoring and funding issues completed, now came the easy part; system installation. Initially, I'SOT expected all installation to be done by September 2003, in time for a ribbon cutting ceremony. Modoc Contracting (MC), the project prime contractor had scheduled project construction to begin at the end of February 2003. When there was no end in sight to resolve monitoring issues, MC found other work. This created scheduling problems that extended geothermal project completion to February 2004.

In May and June, a 5200-foot trench was excavated and a 4 inch PVC pipe installed for discharge to the Pit River. The system mechanical building was also erected. Excavating, for the most part, was easy with a few exceptions. The archeologist monitoring trenching activities only found obsidian chips made by the backhoe. Special attention, with respect to human remains, was given to trenching at the base of a hill above the pasture/wetland. No human remains or cultural resources were found during construction.

During July and August, trenching for the distribution loop piping was accomplished, along with communication conduit. Approximately 6720 feet of preinsulated copper supply and return lines in various sizes and were placed in the main trenches. Over 1800 feet of supply and return 1" insulated PEX (cross-linked polyethylene) tubing was installed from the street to each residence. Under the skirting of each building, 1 inch brass ball shut-off valves were also installed.

From September through February, attention was given to retrofitting building furnaces. This required installing insulated PEX tubing from the brass ball valves at the skirting to the building hot water heaters and from hot water heaters to the coils placed in furnaces. A thermostat, control valve, two temperature sensors and a controller were installed at this time and wired. All the wire for the data acquisition system was also pulled through the conduit that was installed earlier and hooked up to the individual controllers.

On September 26, 2003, I'SOT held a dedication ceremony for the project that was attended by David Rohy PhD., former Vice-Chair of the CEC, Russell Hewett of NREL, Kevin Raf-

Figure 3. Completed central plant with granulated activated carbon (GAC) vessels.

ferty and Gene Culver of the OIT Geo-Heat Center and all the agencies that were helpful during the permitting process. At this time, the mechanical building was equipped with two carbon vessels, boiler, and production pump (Figure 3).

From mid-October through November, mechanical equipment was installed in the central plant along with the ongoing retrofit installation. Main data acquisition control panels and all other system controls were put in during this time as well. On December 5, 2003, the project engineer came to Canby along with the pump contractor for startup procedures. Nine retrofitted structures were now receiving heat from the geothermal system. By the end of February 2004, all project buildings were complete, except for installing a 5000 ft^2 radiant floor slab for the food service warehouse and central laundry.

The I'SOT Geothermal District Heating System

53,000 ft^2 of residential and commercial buildings will be served in the project area. The I'SOT Project will provide geothermal energy for space heating and domestic hot water for 35 buildings. Of these:

- 23 buildings were converted from propane fired systems
- 5 buildings were converted from electrical resistance heating systems
- 3 buildings were converted from water-source heat pumps
- 3 buildings were converted from air-source heat pumps
- 1 future food warehouse and central laundry building will be constructed to use the waste heat from project discharged geothermal effluent

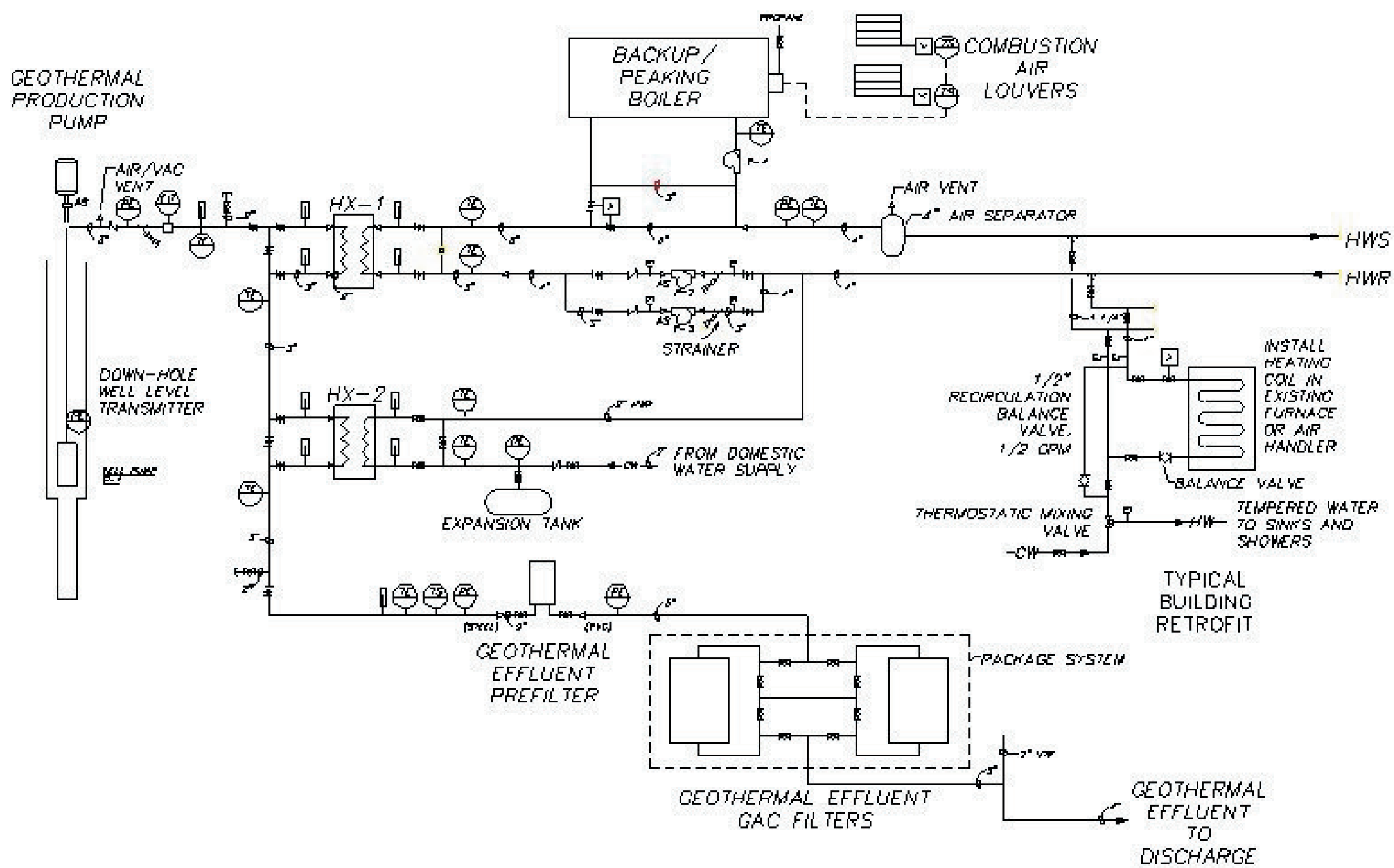

Figure 4. I'SOT geothermal district heating schematic.

Even though a larger percentage of buildings were converted from propane, several large buildings were served by electrical resistance heating systems. While 33 buildings were retrofitted with hot water coils, two received radiant floor systems.

The I'SOT Geothermal District Heating System is unique because:

1. The geothermal effluent is filtered by GAC to meet water quality standards for discharge to surface waters of the United States.
2. An innovative potable water system designed by Brian Brown Engineering of Klamath Falls, OR takes advantage of 2000 gallons of hot water storage in the supply loop piping, lowering retrofit costs.
3. Controls are used to maximize the use of a small geothermal resource (approximately 37 gpm at 190°F) to provide space heat and domestic hot water for marginally insulated residential and commercial buildings. The system can also be operated remotely from another location via the Internet.

A system schematic is shown in Figure 4.

There was a little angst at starting up the geothermal system. Knowing that people do not like change and tend to complain that "things don't work like they used to", I'SOT was pleasantly surprised when those expectations were unfounded.

Marginally insulated buildings and mobile homes with propane heat tend to have exaggerated temperature swings. Supply air temperatures leaving a propane furnace are high (between 120°F - 140°F) so the building heats up quickly, but cools down quickly as well. With the geothermal system, supply air temperatures are lower (between 100°F - 120°F, depending on loop temperature), leaving the furnace blowers to run longer. This creates an even temperature throughout the space. Also, residents loved the fact that they could turn up the thermostat without feeling like their inheritance would be spent on energy costs. Propane in this part of the country can sometimes reach $1.70 per gallon.

GAC Technology Helps Meet and Exceed Discharge Requirements

Monthly water samples for a number of constituents were taken by I'SOT and the CVRWQCB for the first six months. In previous lab experiments, mercury (Hg) removal with granulated activated carbon (GAC) was between 99%-92% effective depending on contact time with the geothermal water. The average Hg concentration before treatment was 206 ng/L; the average Hg concentration after treatment was 7.2 ng/L. I'SOT expected similar results after system startup.

The first six months of Hg removal results, confirmed by the CVRWQCB, exceeded previous lab experiments:

- 281.6 ng/L average Hg concentration before treatment
- 0.98 ng/L average Hg concentration after treatment

Hg concentrations from discharged geothermal water to the Pit River have stayed below 1.5 ng/L. I'SOT was diluting Hg concentrations in the Pit River, whose background Hg is between 5-6 ng/L.

The second visit from the CVRWQCB in mid-March revealed that Hg concentrations after the first carbon vessel were almost at the Hg MCL of 50 ng/L, but after the second vessel still at 1.5 ng/L. Another sample was taken to rule out lab error and in April 2004, the first carbon vessel was replaced by US Filter (USF). Saturation of the lead carbon vessel took place after 2.3 million gallons of discharged effluent that produced approximately 1.39 grams of Hg. When lab analysis was completed on a spent carbon sample, Hg concentration was non-detect at the minimum detection limit of 0.004 mg/L. At this time, USF will replace carbon vessels for $2650 plus per vessel. Much of the cost of replacing spent carbon is the round trip mobilization from the USF plant in Oakland to Canby. The GAC replacement cost will rise to over $5,000 per vessel after four replacements as per agreement with USF. I'SOT will be looking for other avenues for purchasing and disposing of spent GAC in the future.

Per the I'SOT NPDES permit, required constituent monitoring includes:

- Total, Dissolved & Methyl Mercury before carbon treatment each month
- Total, Dissolved & Methyl Mercury after carbon treatment each month
- Total, Dissolved & Methyl Mercury 50 feet before discharge point each month
- Total, Dissolved & Methyl Mercury 450 feet after discharge point each month
- Arsenic and Boron at the well each month
- Arsenic and Boron above and below discharge point each month
- pH and electro-conductivity at the well (weekly and monthly respectively)
- pH and electro-conductivity above and below discharge (weekly and monthly respectively)

Monitoring will be quarterly after the six month data gathering period until the permit is reopened and further negotiations with the USFWS, DFG, and CVRWQCB are completed. Preliminary discussions with the agencies has been positive and the informal talks have indicated they would accept elimination of most monitoring requirements listed above including fish tissue analysis and three species toxicity test as long as the GAC filters are used and replaced as needed.

Projected Savings from Geothermal System

The projected energy savings from the geothermal system are shown in Table 1, overleaf, beginning in the year 2005. 2004 year costs are not included because of extensive monitoring.

Line 1&2 are results of averaging three year (2001, 2002, 2003) project area electrical and propane expenses and conservative estimated savings based on individual building requirements. Line 3 is the estimated annual energy savings

Lines 4-9 list annual estimated expenses. Line 10 shows estimated annual savings for 2005 and beyond.

Table 1. Projected Savings.

1	$20,319.32	total Electrical Savings
2	$23,035.77	total Propane Savings
3	**$43,355.09**	**subtotal annual savings**
4	($400.00)	minus annual discharge permit is $2,000/5 years
5	($1,600.00)	minus CA state discharge fee
6	($1,000.00)	minus annual pumping cost
7	($1,000.00)	minus projected annual water analysis
8	($5,300.00)	minus 2 carbon filter replacements/year
9	($500.00)	minus prefilter cartridges
10	**$33,555.09**	**estimated total 2005 savings**

Conclusions

In 1998, a small community looked into the possibility of reducing energy costs by using a geothermal resource they only thought they had. After committing to a course of action to go forward, I'SOT expected to pay about $200,000 combined with cost shared grants with the CEC and DOE. In the end, I'SOT instead paid about $300,000. At the expected cost savings shown in Table 1, a simple payback of about 9 years will be well worth the I'SOT investment. The I'SOT Community is happy with their accomplishment and the comfort that it affords.

The end of the matter, however, may be that this "little project" will have lasting contributions to the geothermal community that exceed a simple payback value.

Many geothermal projects have been stopped over the years because low levels of mercury could not be mitigated. GAC technology may be able to resurrect some valuable projects and make new ones possible. All participating agencies have a successful project that discharges geothermal effluent to a local river with the permission of the US Fish and Wildlife Service and California Fish and Game. This in itself is a huge accomplishment.

The cost of retrofitting end-user heating systems has been an obstacle to communities wanting to use a geothermal resource. The concept of a potable water geothermal system may influence future design of district heating systems to reduce this cost.

It is being demonstrated in Canby how much can be done with a modest geothermal resource through the use of digital controls and careful design. A direct-use project does not have to produce hundreds of gallons per minute of geothermal effluent to be considered viable.

Table 2. Project Budget.

National Renewable Energy Laboratory	$ 307,000.00
California Energy Commission	$ 304,500.00
I'SOT Inc.	$ 300,000.00
Idaho Operations Office, DOE	$ 204,000.00
Donations	$ 72,000.00
Project Total	$ 1,187,500.00

Acknowledgement

I'SOT would like to thank all of the project participants for their patience and flexibility during the long journey toward a successful geothermal project. It is our hope that supporting this project will also make funding other direct-use projects more attractive.