

ADVENTURES IN THE LIFE OF A SMALL GEOTHERMAL DISTRICT HEATING PROJECT or “THE LITTLE PROJECT THAT COULD”

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ABSTRACT

A small community drilled a 2100-ft 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 250 feet. The method of disposal is to the surface waters of a river after flowing through an activated charcoal filter to remove mercury.

This paper chronicles the three-year evolution of a small geothermal direct-use project from conception to the final stages of challenges that were faced by a small community.

More government assistance is needed to overcome drilling and environmental roadblocks for 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 (Figure 1). 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

need of the farmers, ranchers, government employees, and travelers on their way to someplace else. But Canby, like many other small western towns, has abundant geothermal resources. The American West, still geologically active after millions of years of volcanic upheaval, has yet to realize the full potential of this valuable asset.

As the cost of energy increases over time, there will be more small communities looking at developing the geothermal reserves in their area. There is a great need for state and federal support to help courageous (I do mean courageous) communities that take on projects such as these. If the United States is serious about energy independence, federal and state governments should support geothermal development by funding initial financial and geological assessments and later, environmental permitting and drilling while continuing to support transfer of technological information through Department of Energy funded resources. Small communities do not have the kind of financial resources needed to effectively bring a geothermal project to completion, be it power generation or low-temperature space heating. Important infrastructure could be started at this level before the encroachment of asphalt and concrete that make future development cost prohibitive.

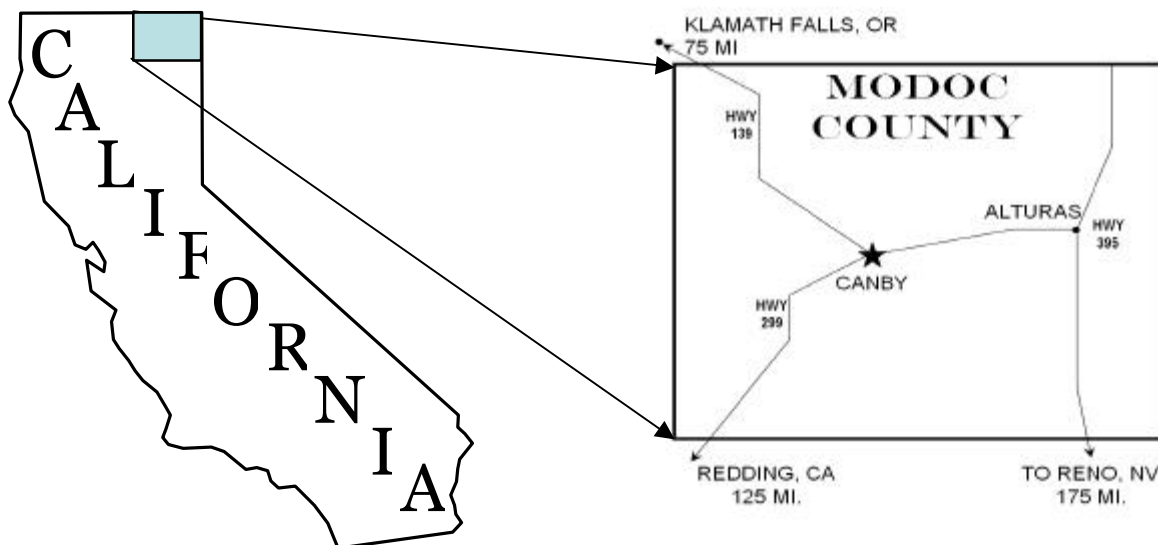


Figure 1. Location map.

A small geothermal district heating project was recently undertaken by I'SOT Inc. located in Canby. I'SOT is a society of people organized since 1969, as a community, exclusively for charitable, religious, and educational purposes within the meaning of section 501-c-3 of the Internal Revenue Code. I'SOT owns and operates a rural health clinic and low-income housing. Many I'SOT members work in a licensed 30-bed group home for juveniles. A nine-member Board of Directors voted by the membership, rotating every three years, makes community business decisions. I'SOT is an integral part of Modoc County activities including annual Children's Fair, Health Fair, and other public events. I'SOT has participated on the Modoc County Grand Jury, Hospital Board, Planning Commission, Child Protective Services, and Mental Health Committee.

I'SOT spends between \$21,000-\$42,000 annually in propane costs for residential space heating and domestic hot water, depending on the price of propane and the duration and harshness of the winter. While drinking 87°F tap water from our community well and having other evidence of geothermal activity in the area, it seemed that there was a possibility of reducing these energy costs.

PRELIMINARY INVESTIGATION

In May 1998, I was a civil engineering student at the Oregon Institute of Technology (OIT) and an I'SOT member, which had several advantages. As a student, I could work some of the geothermal project into my coursework for college credit and there was constant access to OIT Geo-Heat Center (GHC) expertise. Secondly, I could devote the amount of time the project demanded without worrying about income. These advantages were essential for the challenges ahead.

As the principal investigator for I'SOT Inc., I solicited the help of the GHC to determine the geothermal potential on I'SOT property. Kevin Rafferty of the GHC came to Canby and dropped a temperature probe down our community well to get the data needed to plot a temperature gradient. The gradient he found was similar to geothermal wells in the town of Alturas, twenty miles away, being 7°F/100 ft. It was estimated that at 1600 feet of depth, a water well driller would be able to find 150-200 gpm at 150°F-160°F. Records of other deep wells in the area verified this possibility. A hot spring two miles away that discharges 500 gpm had very good quality water and our hydrologist believed that our well would intersect the same aquifer. Preliminary estimates were made about how much the entire project would cost and we could expect would save annually. Assuming that our resource had the anticipated flow and temperature, we expected to capture 95% of annual space heating costs. This was all encouraging news, but we didn't have the money to drill a well or establish the infrastructure for a district heating system.

The I'SOT Board of Directors decided to go forward with efforts to obtain government funding for a district heating system. The unique nature of the I'SOT community allowed for the project to be based on 100% market penetration. This is an essential difference from most communities as maximum

penetration is not always achievable. Another positive aspect of the project is that concrete and asphalt have not taken over the town, keeping trenching costs to a minimum.

OBTAINING INITIAL GRANTS

In August 1998, a solicitation from the USDOE Idaho Operation Office offered a 75%-25% grant to drill an exploratory geothermal well. I'SOT proposed to drill a 1600 foot geothermal well, space heat about 53,000 ft² of residential housing, and create a 15-acre warm water wetland as a way to dispose of the geothermal effluent. After all, there was one two miles away that was a gathering place for all kinds of wildlife. We submitted a proposal with help from the GHC and won an award to drill our well--IF, we could get another award from the California Energy Commission (CEC) to fund material for a district heating system (Figure 2).

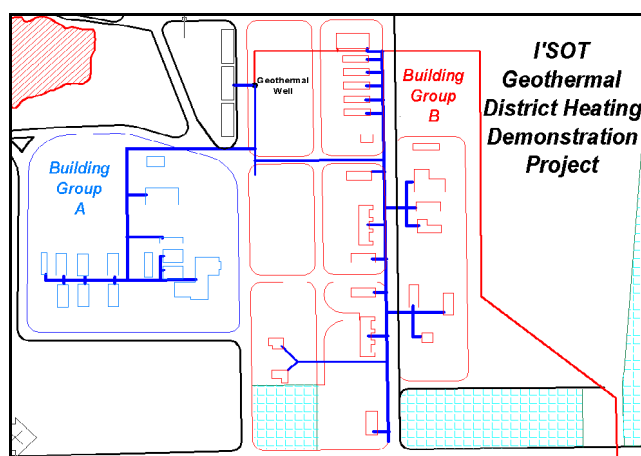


Figure 2. Proposed district heating layout.

In January 1999, a geothermal R&D solicitation from the CEC came out, but it was not particularly friendly to direct-use projects. Although I'SOT was "encouraged" to participate, we were told privately not to get our hopes up as staff recommendations no longer supported direct-use projects because of the low cost of natural gas, a situation that no longer exists. Through contacts and a little luck, we arranged a meeting with Dr. David Rohy, then Vice-chair of the CEC. It was through Dr. Rohy's support that we got a materials only award for \$304,525 contingent on getting a viable geothermal resource through our partnership in the DOE drilling.

Up to this point, efforts toward our project goal were going well. We just had won two awards back to back and everything seemed like we would have our project completed within the year. Obtaining grants based on reasonable assumptions was the easy part.

PERMITTING AND THE SEARCH FOR A DRILLER

Going into this adventure, it was not clear to us exactly how much permitting was involved. The initial environmental assessment (EA) by the California Division of Oil and Gas as the lead agency was done expeditiously, begin-

ning in July 1999 and ending in September 1999 with a Negative Declaration. The County Use Permit to drill was another matter, however, and that permit wasn't obtained until December 2000. There is a saying that the "wheels of government grind slowly." It's true. By this time, winter had set in and the time for drilling that year was gone.

We had also gotten bad news on our drilling solicitation. Out of 17 drilling companies that were sent bid packages in August 1999, only three responded with bids that were twice and three times the amount originally estimated. Several things factored into the bids being so high. First, drillers were busy and didn't need the work. Second, drilling on the Modoc Plateau is not an easy task with alternating zones of lost circulation and sticky volcanic tuff, so it has a bad reputation. Unknown to us at the time was that drilling in this area requires a larger drilling rig with the hydraulics to blast through the tuff zones. Regular water well drillers protect themselves by estimating the worst case scenario. Our drilling budget with the DOE prevented obtaining a larger drilling rig and we thought we could negotiate with a driller of good reputation and take our chances.

By January 2000, the CEC gave I'SOT a March 31st deadline to sign a driller. Even though I'SOT had started permitting two months before award, the CEC felt that I'SOT had not achieved significant progress toward our project goals.

A driller was signed on March 7, 2000, not knowing if that was good or bad news. I'SOT knew the CEC funding was safe for the time being and we hoped for the best during the drilling process that would commence the first week in April. In the initial drilling estimate, California required blow-out prevention equipment, which was not considered as we were going after 150-160 F water. It was worked out with the DOE to use all available funds to drill the well. I'SOT made plans with our consultant to supervise the drilling but be in close contact to also save money. (See GHC Quarterly Bulletin, Vol. 21, No. 4, Dec. 2000 - "Drilling Geothermal Well ISO" for details on the drilling project.)

LET THE GAMES BEGIN

I'SOT began drilling our geothermal well on April 6, 2000, which was estimated to take up to three weeks (Figure 3). It took three months. The soft volcanic tuff formations we encountered made drilling difficult. Day after day, the people in the community would ask if we were getting close. After eight weeks and no water at 1600 feet (the original estimated depth), I'SOT took a temperature log of the well and found about 160EF at 1600 feet, which verified the original estimate. Our consultant said to prepared to drill past 2100 feet. A decision was made to case the well and drill until 2000 feet.

After casing the well to 1600 feet, drilling resumed and within a week we were at a depth of 1950 feet and still in the soft tuff. Another temperature log revealed a temperature of 208EF. It was getting hotter, but still we had no water. The I'SOT hydrologist was encouraged because the cuttings were beginning to be lithified from the heat and began to look like the cuttings of another geothermal well in Alturas that was successful. Another decision was made to borrow more money and drill until we got a resource.



Figure 3. Drilling the well.

We found our resource on June 8, 2000. The drilling went to 2100 feet and a log was taken to find out what we had. The log said that the bottom-hole temperature was 223EF and an "educated" guess at the flow was somewhere about 200-300 gpm according to the technician doing the monitoring. Even if we didn't have that much water, we felt we had enough.

The big day came when the driller was going to develop the well or bring the water to the surface to find out what it would produce. We waited, and waited, and waited until we were told that the well was "plugged up" and it would cost more money to unplug it. With more borrowed money, we contracted the driller with the help of the consulting firm GeothermEx, Inc. to explore ways to solve this problem.

The first method that was used was referred to as "water stimulation;" where, water was pumped down the well at a rate of 350 gpm at 250 psi. This was done to remove any obstructions outside of the liner that was placed between 1600 and 2100 feet, and to make the aquifer possibly more productive. This method was unsuccessful.

More investigation revealed that there was sediment inside the liner up to about 1900 feet. More money was borrowed to rent a large compressor and experts to remove the sediment. By June 6, 2000, we had a resource, but it wasn't what we had expected. A pump test would have to be done by a hydrologist to determine what the long-range productivity would be.

The end of the drilling story is this: A \$192,000 project ballooned to about \$450,000 and a resource that was so small it was scary. You can imagine the angst the community felt after pouring all of this money into a hole in the ground (Figure 4). The DOE kicked in another \$60,000 for cost overruns. In the end, a \$48,000 drilling project for I'SOT ended up being around \$250,000 with the DOE portion being about \$204,000. The only other worse case scenario I imagined at this point was to not find anything at all.



Figure 4. The wellhead.

PENNILESS BUT HOPEFUL

After the drilling was complete, we were in hard straights financially and the last thing the Board wanted to hear was that another \$11,000 was needed for a long-term pump test and a hydrologist report. This was needed to verify to the CEC that we had a viable resource. In September, the I'SOT Board of Directors approved the funds and the results were given to the GHC for analysis in October.

The hydrologists report showed a long-term productivity rate of 37 gpm at about 180-190EF. Such a small resource for so much money we thought. However, the GHC report said, *"it remains possible, provided careful design, to capture virtually all of the anticipated space heating savings."* We were encouraged by the report, but something else was beginning to change our original plans.

WATER QUALITY AND THE CALIFORNIA TOXIC RULE

Although the water chemistry seemed to be good, the arsenic concentration was about 95 µg/L which is above the drinking water standard. And even though we are not drinking the water and the hot springs two miles away grows fish in the same water, we now have a disposal problem. The Central Valley Regional Water Quality Control Board (CVRWQCB) now suggested that we plan to dispose to the Pit River one mile away. The proposed wetland that we had wanted to develop was now, for all practical purposes, impossible. To do a wetland now meant that we had to drill monitoring wells around the perimeter of the wetland and monitor monthly. If the arsenic concentration increased in the local groundwater, we would have to shut down. The CVRWQCB was positive this would occur. The decision was made to dispose to surface waters of the Pit River.

This created a problem for the CEC. They felt it was a change of scope to change disposal to surface waters. After spending close to \$450,000 to drill for a resource, this was not acceptable to I'SOT. I'SOT assembled a geothermal expert, a regulator and a staffer from our State Senator's office, along with I'SOT representatives for a meeting with the CEC that brought positive results. I'SOT and the CEC would work

together toward a no-cost time extension, as a time consuming National Pollutant Discharge Elimination System (NPDES) discharge permit would now be needed.

To add to our dilemma, California had recently adopted more stringent water quality regulations as contained in the California Toxic Rule (CTR). The maximum concentration for arsenic was lowered from 50 µ/L to 10 µ/L. We began taking samples of our effluent. CTR testing began which tests for every known pollutant in two different seasons, winter, and summer. About \$16,000 was spent on pump tests and CTR testing. I'SOT also was in the unfortunate position of being the first discharger to go under the new CTR regulations. This meant that everything had to be done by the book, and more. The CVRWQCB didn't want the embarrassment of not doing their first NPDES permit under the CTR discharge correctly.

The CVRWQCB also needed a licensed hydrologist to do a mixing zone study to determine dilution credits. This \$1,500 report was done along with learning a computer modeling software developed by Cornell, available through the USEPA, to model the mixing characteristics of our effluent. The results of the hydrologist report and the CORMIX modeling helped the CVRWQCB define a mixing zone.

An injection well would have eliminated the needed of all the environmental permitting to come, but at an additional expense of \$350,000+.

WATER QUALITY AND THE M-WORD

In January 2001, I met with a representative of the CVRWQCB at our well site and we grabbed a sample of effluent from the wellbore (static water level is 20 feet). It was an ugly, cloudy sample, but we tested it for low-level mercury. The sample only had a concentration of 7 ng/L. In August 2001, at the end of our CTR testing, the regulator decided to check one more time for mercury; only, this time the concentration was 120 ng/L--over six times the traditional EPA aquatic threshold. I'SOT felt that the number was high because the sampler did not follow the strict protocol necessary for ultra-clean sampling. We sent several samples to Frontier Geosciences of Seattle, a leader in mercury research. Results confirmed that I'SOT now had a mercury problem.

The CEC became more nervous by the day because there have been other geothermal projects shut down in Modoc County because of mercury. This was one more place that the CEC became uneasy about the I'SOT project, but in this case with good reason.

It was now September 2001 and a way to mitigate the mercury problem was necessary to save the project. I'SOT sent several gallons of our effluent to Frontier for mercury removal experiments costing \$4,000. The lab told us that activated carbon (AC) may work for but wanted to set up a pilot optimization study for another \$10,000 and then make a recommendation. Also, for a price of \$150,000, Frontier would design an AC system that would mitigate the mercury to under 10 ng/L. This was not an option.

This price was not an option, but maybe the process was. I'SOT mirrored an experiment that Frontier did at Basic Labs of Redding and found that AC removed 99% of the mercury on our effluent. We also did another \$4,000 experiment that modeled the detention time of a commercial granular activated carbon (GAC) from USFilter with the same results (Figure 5). Interestingly, industry has very little data on mercury removal from geothermal water with GAC and our data is of interest to USFilter. These experiments were essential to get our NPDES discharge permit.

All agreed, except for the USFWS, that our small discharge and extraordinary mitigation measures were no measurable threat to the Pit River or to the creatures that populate it. It was also unfortunate that I'SOT had to agree to \$5,000 more effluent monitoring in the first six months of operation in order for the USFWS not to contest our discharge permit. The U.S. Environmental Protection Agency (USEPA) wrote a letter stating that the effluent monitoring for our project was excessive and recommended reduction after the first year.



Figure 5. *Activated carbon filter.*

With the CTR sampling done, the mercury mitigation looking promising and the support of the USEPA, CVRWQCB, Modoc County, and California Department of Fish and Game, I'SOT obtained a NPDES discharge permit on April 29, 2002.

ADD ANOTHER FUNDING AGENCY, AND STIR

As if there wasn't enough uncertainty already, in January 2001, the National Renewable Energy Laboratory (NREL), a DOE funded lab, sent out a 50-50 cost-share, direct-use solicitation that offered to fund permitting,

engineering, and installation in two phases for selected projects. This was an opportunity to match \$304,525 in CEC materials-only funding. It would also be a juggling act to start doing business with NREL and CEC as the agencies have different reporting, engineering, funding requirements, and construction time lines.

Nevertheless, a proposal was written in February 2001 to answer the NREL solicitation for Phase I funding that would pay for engineering a district heating system that would otherwise be paid by I'SOT. We initially had difficulty giving NREL the kind of proposal they were expecting because we had only answered solicitations for grants before and now we were trying to do one for a contract. Although our project was still evolving because of water quality issues, the NREL staff was very patient and with their support, finally entered a Phase I contract in January 2002. If I'SOT were to enter a Phase II contract with NREL for installation, we would be required to furnish them with two years of data, monitoring, and limited technology transfer.

Entering into the construction phase of the project with a federal program, however, presents even more environmental paperwork and delay. Even though all environmental requirements were satisfied to receive state funds, the federal government requires NREL to complete a separate environmental review before disbursing federal money. At this writing, a decision has yet to be made about whether to receive federal funds to construct the project.

CONCLUSIONS

Although the I'SOT Geothermal Project has experienced probably every issue that can be faced on a small project, it is important to note that most of the agencies mentioned in this paper have been as accommodating as possible to help forward this project.

The employees of the CVRWQCB, California Department of Fish and Game, and the USEPA were all very helpful; although, they are themselves enmeshed in ever-changing environmental regulations that are many times political, sometimes scientific, and always conflicting. It is hoped that the future of the environmental regulation takes a more holistic approach to projects rather than it does at present.

Finally, it takes community support, both financial and moral, to develop a direct-use geothermal project. Most projects that fail, fail because the community involved doesn't have the time, cohesiveness, tenaciousness, or courage it takes to follow through to the end. Those are properties of a community that cannot be imposed on by government, but must come from within the community itself. If a funding agency is fortunate enough to find a group of people as described, they should do what ever is necessary in the way of support. These partnerships can serve as examples of what can be done when government agencies and the public working together to build tomorrow.