DOE/R6/10974--T1

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DE84 003450

APPROPRIATE TECHNOLOGY SMALL GRANTS PROGRAM
GRANT NO. DE-FG46-79R610974
FINAL REPORT

Lightning Dock Geothermal Space Heating Project
Lightning Dock EGRA, New Mexico

MASTER

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I SUMMARY OF PROJECT

The project incorporated and/or used existing facilities, as per the grant application, as well as the construction of economically more feasible new structures. re: page #2, quarterly report, Jan. 11, 1980 and "B", section II, this report.

Two Reda, three phase, submersible pumps were installed in November, 1979, as well as the above ground well head piping with all-brass control valves, temperature and pressure gauges. Three phase electric cable was used with magnetic starters, heat elements, fuses and lightning protectors; all safety precautions against the loss of a pump motor which might result with the loss of one phase of electric power.

Black, 1 $\frac{1}{2}$ " pipe was installed to inject cold water into the well, breaking the steam build-up and keeping the pumps from serging. re: "B", section II, this report.

The geothermal water leaving the well head is split in two directions, with all but approximately four gallons per minute being piped in to the Flora-guard heat exchange system units, to heat an existing foliage greenhouse of 3600 sq. ft.. re: "A", section IV, this report.

The diverted geothermal water, approximately four gallons per minute, enters the booster pump and is piped to a home Modine heat exchange system unit installed in the attic of an approximately 2000 sq. ft. home. This unit was connected to the existing central heating and cooling duct work.

Both Reda pumps operated as expected until Jan. 4, 1980, at which time one of the pumps malfunctioned and was removed from the well. The problem was defined as a break down of the motor insulation, caused by the instantaneous heat change, to an already hot motor, each time the pump "kicked on". re: "B", section II, this report.

The partially heat extracted geothermal water, from the home heat exchange unit is piped back to the well head and reinjected into the pipe system to the greenhouse. The geothermal water leaving the greenhouse is still only partially heat extracted and is piped into the heat systems of the nursery-bedding plant structures.

Basic, but extensive changes were made in the project proposal for the nursery lath house. Consulting with a building firm and further investigation into nursery environments and growing led to the decision to abandon the proposal of using the existing glass side wall, wood frame structure. A metal framework structure was decided upon and divided into two separate units. re: pages #2 and #3, quarterly report, Jan. 11, 1980 and "B", section II, this report.

Depending upon the season and the outside temperatures, the geothermal water leaving the nursery-bedding plant structures is piped into a water reservoir or enters a booster pump to the drip system of the orchard. The function of this system being to prevent spring killing frost to the fruit trees. The system was installed in April, 1980 and is being used, with non-geothermal water to irrigate thirty-two fruit trees, this summer. re: "B", section II, this report.

A continuing problem, in arriving at the point to where the project could be completed, has been the fact that the project location is rural. The projected intention was to put labor dollars into the community through the use of local labor, materials, and machinery. Doing this resulted in excessive progress delays. On site freight delivery delays were another constant and unsolved problem from the date of project initiation to completion. re: page #1, quarterly report, Jan. 11, 1980.

II TECHNOLOGICAL REPORT

A. Technological Overview

1. Existing on-site facilities Before the grant award was made.

- Three phase electrical power
- Geothermal well, tested at 215 F
- 3600 sq. ft. glass and fiberglass, wood framed greenhouse
- Electrical and technical mechanisms, installed for use in the above greenhouse:
 - a. thermostatic controls
 - b. fans
 - c. humidistats
 - d. fertilization systems
 - e. irrigation system
 - f. thermometers
 - g. pressure pump
 - h. recirculating pump for air conditioning system
 - i. evaporative air conditioning system
- Tested 224 tds irrigation water, analysis NMSU
- Reinforced glass side walls of unfinished nursery house - use of which, as part of the proposal, was later abandoned
- complete duct work for heat exchanger in home of approximately 2000 sq. ft.
- acreage within feet of existing geothermal well for use as an orchard
- reservoir for heat extracted water - water to be used for livestock

2. Projected project under the grant proposal.

The proposed project was to take the existing geothermal greenhouse and home heating systems, which consisted of pumping geothermal water and steam through passive steam heaters, and convert the systems to one using modern heat exchange units. This method was proposed by Dr. LaFrance, N.M.S.U., research grant publication, "Heat Exchangers for Geothermal Use", 1977.

It was proposed to complete the existing unfinished, re-inforced glass side wall, wood framed structure, as a nursery lath house. The purpose of which would be to use geothermal water in implementing university concepts on the advantages of bottom heat to establish hardy root systems in nursery and bedding plants. The use of this framework was abandoned in favor of erecting new structures for the proposed purpose. re: "B", section II, this report.

The final project of the proposal was the establishment of a drip irrigation system, to an area just west of the existing greenhouse and within feet of the geothermal well. Through this drip irrigation system geothermal water would be pumped, to prevent killing spring frosts. The purpose of this area of the proposal is to increase the potential use of existing geothermal waters of the Lightning Dock KGRA, in opening a new geothermal agri-industry which is economically feasible for the area and would be extremely energy efficient.

B. Details of the Completed Individual Project Units

1. Pumps and pumping of Geothermal hot water and steam.

The existing geothermal well is a six inch well, 100 feet in depth, with a temperature of 215°F; testing done by New Mexico State University, Las Cruces, New Mexico. The well will pump approximately twenty-five gallons per minute, of hot water and steam. Pumps of various designs; jet, turban, pump jack, and submersible have been experimented with and used in this existing well over the last ten years. The fact that the well itself is a 6" well and pumps only 25gpm, as well as the temperature being 215°F, has contributed to the pumping problems. Many manufacturers of both turban and submersible pumps have available large models designed and insulated to withstand operating temperatures of 330°F and more. Pumps of a smaller design, by these same manufacturers, designed to pump 20gpm are available and advertised to withstand high operating temperatures but are not guaranteed. The years of experimentation have resulted in finding the use of a Reda, three phase, submersible pump to be the most reliable, most economically feasible, easiest to handle and longest lasting.

When pumped the water tends to break into steam, causing a serging of the pump motor. This continuous serging can and does lead to excessive over heating of the motor and/or cracking of the motor seals, resulting in the loss of the pump motor.

The success of the proposed project, geothermal space heating, depended completely upon pumping the geothermal water and steam. Under the proposal, two Reda, all-brass, geotrol lead, carbon ceramic sealed, specially insulated, three phase submersible pumps were purchased and installed, using a Reda Co. #10 - 3JC-IND thermally protected electrical cable, magnetic starters, heat elements, fuses and lightning protectors. The pumps were installed on November 15, 1979, by a local water systems contractor. A 1½" black pipe, for cold water injection, was installed, with the pumps, on the same date.

As was explained, in paragraph two, page #3, of this section, the water when pumped, tends to break into steam resulting in the serging of the pump motor and eventual loss of the motor. Through experimentation it was discovered that a steady stream of cold water would substantially reduce the steam, without reduces the water temperatures to any great degree. The amount of cold water injected to reduce steam is dependent upon the temperature of the non-geothermal water itself; early fall and late spring requiring a greater amount than in mid-winter.

The cold water is available from a non-geothermal water well 1½ miles west of the greenhouse. This water is used in the greenhouse for irrigation. A "T" was installed in the main water line, with a valve and faucet to the geothermal well.

The pumps are thermostatically controlled through relays to the magnetic starters. As was proposed, the pumps are used alternately, one pump acting as a back-up in case of mechanical breakdown of the operating pump or severe cold weather; at which time the back-up pump thermostatically "kicks on".

Both pumps operated as expected until Jan. 4, 1980, when one pump malfunctioned, thermostatically putting the back-up pump into operation. Contact with the company representative and subsequent return of the pump to the factory, led to the decision that the problem lay in the motor insulation. Thermostatically controlling the pump, meant that it kicked on and off several times per day, maintaining the necessary greenhouse temperatures. This resulted in instant heat changes, breaking down the insulation around the motor. The company did eventually discount and ship a new replacement motor.

It had not been included, intended, nor expected that any experimental or mechanical design work be developed or tested, under the project. Because of the loss of the one pump, due to over-heating and the resulting break-down of the motor insulation, I did some more work on a rudimentary design that I had been considering a few years before I tried the first specially built Reda submersible. The ultimate goal would be to externally lower the temperature in which the pump motor must operate without substantially lowering the geothermal well temperature. The resulting design was a crude casing for the pump motor, which I refer to as a "water jacket". On paper, if successful when built, installed and tested, the jacket would have a dual purpose; the external temperature immediately surrounding the pump would be substantially lower and with the exit point directly below the pump itself, the water would be prevented from breaking into steam, therefore, no motor surge. I built the design and attached it to the new motor. re: "C", section IV, this report. It was installed the last week in Jan., 1980, and with four months of use it looks to be the answer. When the pumps were removed from the well, for the summer, the first week in June, and inspected, it showed no break-down in insulation, no electrical leakage, or excessive wear.

The pumps will be reinstalled in late August, both with "water jackets". A complete pumping season, fall, winter, and spring, should make the results conclusive.

At the above ground, well head, the piping system includes all-brass control valves, temperature and pressure gauges.

2. Greenhouse space heating

The geothermal water and steam is split in two directions, at the well head, with all but approximately four gallons per minute being piped into the 3600 sq. ft. greenhouse. The geothermal water and steam passes through the existing passive steam heaters and enters a Modine Flora-guard heat exchange system. The fan backed system forces the extracted heat through a 24" diameter, collapsible plastic, convection tube, located below the westside pot bench, dispersing the hot air into the greenhouse, just at floor level.

Installation of the Flora-guard system, at ground level, with the convection tube installed under the pot benches, was due to the impossibility of installing one or more units at roof level.

The existing greenhouse, used in the space heating project, is built with reinforced glass side walls and a wood framed, fiberglass paneled roof. Roof support poles are spaced down the center and the pitched roof is only 10 feet at its apex. The side walls are 6 feet high. The only available space to install a heat exchange system was at floor level along the side walls, under wire mesh pot benches where the passive steam heaters were spaced.

Most conventional greenhouses, due to the necessity to use every inch of available floor space, suspend the heating systems from the roof, regardless of the type of units or heat source.

The necessary placement of the heat exchange system and convection tubing under the pot benches, resulted in an unexpected, but positive benefit. The floor level dispersment of the geothermally heated air allows for a filtering effect through and around the foliage pots as it rises in a clockwise movement toward the roof level. This dispersment warms the soil contained in each pot, as it rises in a natural flow upward. The conventional placement, at roof level, of most heat systems, forces the heated air

in an unnatural pattern, downward on top of the dense foliage. With this system the soil temperatures within the pots is lower, the foliage itself acts as a natural barrier to the heat reaching the floor levels of the house, and therefore necessitates the consumption of greater amounts of fossil fuel to maintain the required temperatures. The reasoning behind conventional placements of greenhouse heating systems is a carry over from the economic past. First, and foremost, each sq. inch of floor space, that could be occupied by foliage or flowers meant gross profits, while physical non-accessible roof space was lost space economically. All that was necessary was to elevate the roof level a few feet and construction costs, at that time were nominal. Lastly, even though suspending the heating system would require the consumption of greater amounts of fossil fuel that cost per gallon was far less than the costs involved in cooling and the higher roof levels would enhance this aspect.

3. Home space heating.

Approximately four gallons per minute, of the geothermal water and steam, is diverted, at the well head, and piped into a Modine, 63,000 BTU, forced air, heat exchange unit. This unit is installed in the attic of an approximately 2000 sq. ft. home. The heat exchange unit is connected to the existing central heating and cooling duct work. A connecting piece of duct work was necessary, between the unit and the existing duct work system. This work was done by an area sheet metal shop. The connecting section, first completed and picked-up the last week of Jan., 1980, was a miss match and required reworking. The new section was completed in Feb., 1980, and the unit was installed in March.

The partially heat extracted geothermal water leaves the home heat exchange unit and is piped back to the main well head piping into the exist-greenhouse.

Because of the late season installation and completion, of the home space heating system, a conclusive result, of the efficiency of the system will not be possible until its use through the winter season of 1980-1981. The use of the system, in the spring months, did point out the following:

- a) the house was kept comfortably warm during the colder days of the spring
- b) there seemed to be a physically beneficial increase in the humidity within the house. Noticable by condensation of moisture on the window panes and less dryness of the nasal membranes.
- c) humidity condensation, on the window panes, resulted in the cracking and peeling of the paint on the window frames and sashes.

4. Nursery-bedding plant structures.

The projected proposal called for the completion of an existing wood framed, glass sided structure, into a nursery area, utilizing bottom heat to stimulate root growth. As outlined in the Jan. 11, 1980, quarterly report, this area of the project was reconsidered and basic but substantial changes, in construction, were decided upon.

It became more economically feasible and structurally feasible to abandon the existing frame work in favor of erecting new metal structures. A

metal structure would be more stable and allow a greater flexibility, as well as give a much more presentable look. It had been pointed out, by the university, that the existing framework would be too great in length to allow for accurate controlling of the environment.

The metal framework was purchased and divided into two separate units, to allow versatility in temperature control, light, and humidity. The erection of the framework for both houses was completed in March and the installation of all water, fertilizer and geothermal piping, to the structures was complete in the late spring.

Further investigation into nursery and bedding plant production made it evident that if covered in lath only, the structures would be both defeating to the success of the project and self defeating to my business, because it would force me into a retail marketing situation where there is no retail market.

The use of lath, as a covering, would limit the use of the structures to the finishing and/or holding of a plant product "grown" in another area of the country. To prove the benefits of bottom heat in stimulating root growth, and to promote the economic growth of geothermal greenhousing, the plant product must be grown here. Therefore, the structures have been covered with fiberglass, at this time.

Air circulation and cooling systems have been installed in the larger of the units, with forced air heating in the smaller unit. The final check for the grant award will be used to install the air circulating and cooling in the smaller unit.

A bottom heated seeding bed will be used to sprout seeds which can then be transplanted and brought through all stages of growth as a geothermally produced nursery product.

This process, from seed to marketable product will require more time than does the production of a marketable foliage plant. Until the point can be reached where all floor space, in the new units, are occupied with nursery plants, the units will be used in the production of foliage plants and bedding plants.

The partially heated extracted geothermal water leaves the heat exchange systems of the original greenhouse and is piped into the heat systems of the new nursery-bedding plant structures, after which it is piped into a water reservoir or, depending upon the weather, enters a booster pump to the drip system of the orchard.

5. Orchard drip irrigation.

The final project under the grant award was to design and install a drip system in an area immediately west of the existing greenhouse.

The total two acre area will eventually be an orchard containing a wide variety of fruit trees, all irrigated through the water saving system of drip irrigation, and protected against killing spring frosts through the use of geothermal water in the same system.

The booster pump, lateral lines and drip system were installed and completed in April, 1980.

Thirty-two, two year old, 1-1½" caliper, bare root fruit trees were planted in May, 1980. The trees planted included, nine apple trees in four varieties, six peach trees in two varieties, six plum in three varieties, three cherry and two fig trees. At this time all but eight of the trees have established themselves. Other plantings are intended for this fall and the spring of 1981.

III CONCLUSIONS, RECOMMENDATIONS, SUGGESTIONS

Costs have been held within the grant award, for the projects awarded. With the final portion of the grant funding the project will have been completed under the grant awarded.

The project has been an ultimate success, one which can be pointed to with pride. The success of this project will go a long way in promoting the alternate energy value of our geothermal resources and the Department of Energy's alternate energy use development program.

More conclusive results as to the benefits derived under the project will be evident in the months to come, though basic results have been recorded as the various areas of the project progressed toward completion.

The geothermally space heated greenhouse area produced an efficiently controlled environment, during the months from Nov., 1979 through May 1980. The temperature variance, from 65°F nights and 75°F days, was seldom off more than five to eight degrees.

Continuous air circulation almost totally eliminated water condensation on the roof area. A problem which with the passive geothermal heating had caused rust on the foliage leaves.

The natural flow of the geothermally heated air, from the floor level, in a clockwise motion, toward the roof level, produced a more even distribution of heat and a more uniform temperature throughout the greenhouse.

This heat flow, in its natural pattern, produced an unexpected benefit, in that pot soil temperatures were warmer, resulting in a more even foliage growth, a denser foliage and cut production time, from cutting to marketable product, by an estimated two weeks.

More accurate fertilization and watering schedules were possible, because the heat distribution and air circulation resulted in a uniform drying of pot soils.

With the results of floor level heat dispersment, experienced with the Flora-guard heat exchange system, it is felt that the supplying of bottom heat, to nursery and bedding plants, will undoubtedly give the positive results looked for in the new facilities.

The benefits of home geothermal space heating will be conclusive during the 1980-1981 winter season. Those benefits recorded in the short spring 1980 use period, were positive in nature. The home environment was physically comfortable, basically more energy efficient, and undoubtedly safer, with the elimination of highly volatile propane heating.

The increase in the humidity, in the home, should provide a more healthful environment and reduce respiratory dryness.

If a new home were to be constructed and designed to use geothermal space heating, my recommendation would be , to install the geothermal forced air heat exchange system and its accompanying duct work, below the floor with floor level outlets, rather than in the ceiling. This would result in a more even distribution of the air and a more uniform floor to ceiling temperatures.

Because of the increased humidity and condensation of water, on glass window panes, steel casement windows would be economically more feasible than wood frame windows and sashes.

One of the far reaching, and almost impossible to measure, yet basic motivations for this proposal, was to demonstrate the economic feasibility of the development of geothermal resources for non-power uses.

New Mexico has vast areas of geothermal resources, which can be developed for use in commercial non-power industries. Most of these industries are agriculture-related — for a State which is dominately agricultural.

The greenhouse horticultural industry is no longer economically feasible in those areas of our country where vast amounts of fossil fuels must be used to maintain the greenhouse environment. Each year more greenhouse businesses close their doors and each year new facilities are opened in the southern and southwestern areas of the United States. These new facilities still require the use of fossil fuels, even though the total need is far less than was consumed in our colder climates. Why not New Mexico? Why not geothermal heat rather than fossil fuels?

The agricultural industry in the State of New Mexico and in Hidalgo county is in an economic depression. Prices are low and expenses are even higher. Geothermal energy development, in this State and in this county, would give the agri-industry and agri-related businesses a shot in the arm toward recovery, if apathical attitudes could be stimulated.

Geothermal energy used in the space heating of greenhouses — results — a new agri-industry with the necessary agri-related businesses necessary to supply, maintain, transport and retail the production.

Geothermal energy used to defeat the killing spring frosts in fruit orchards — results — a new agri-industry and its necessary agri-related businesses.

Geothermal energy used to dehydrate and process food crops — results — a new agri-industry and its necessary agri-related businesses.

Geothermal energy used in the production of gasahol — results — a new agri-industry and its agri-related businesses, a shot in the arm to depressed farm production.

Geothermal energy used in the wool washing process; New Mexico produces a percentage of the nation's wool, most of it sold to Burlington Industries, North Carolina, who ship it to Colorado and Texas, to be washed before going to the eastern mills — Why not here? Using geothermal energy the wool could be washed much more economically and it would keep some of those wool industry dollars at home.

This stimulation of a sceptical populace, in a apathetic society, will not be measurable in any short span of time, but there has been a definat interest created in the local community. Many of the farmers and agri-related businessmen have begun to investigate the feasibility of the dehydration, of farm crops, as well as the production of ethyl-alcohol, though the dominating attitude remains, "lets wait and see".

IV APPENDIX

A. Photographs.

heat condensation
tube

Large Nursery - Bedding House

Nursery - Bedding Plant House

Large Nursery - Bedding
House

Back View of both new facilities

Apple tree - June

Large House interior

Drip irrigation - July

B. Illustrations.