MASTER

at New Mexico State University

FEASIBILITY STUDY OF GEOTHERMAL ENERGY FOR HEATING GREENHOUSES

FINAL REPORT

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Final Report
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Principal Investigator:
Leo J. LaFrance, Ph.D.
Department of Mechanical Engineering
New Mexico State University

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CHAPTER II

The first part of the chapter is devoted to a discussion of the various methods of determining the rate of reaction. The second part is devoted to a discussion of the various factors which influence the rate of reaction.

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ABSTRACT

The Technical Feasibility of Heating Greenhouses with geothermal heat is established. Off-the-shelf equipment suitable for geothermal heating is readily available. A procedure is given to economically examine a geothermal site for its suitability. Generally, geothermal heating systems are capital intensive. Where the geothermal energy is "Free" the geothermal system is very attractive and where the cost of geothermal heat is the same as other energy, BTU/\$, geothermal heat is unattractive.

INTRODUCTION

New Mexico, because of its mild climate, is an ideal place for greenhouse production of vegetable and ornamental crops. The state is also ideal because of the high light intensity. The high light intensity is due to the elevation and dry climate. New Mexico is also rich in geothermal energy, and this is the reason for this study.

The objectives of the study are to:

1. Establish the technical feasibility of heating greenhouses with low temperature, 212°F (100°C) and below, geothermal sources.
2. Establish the economic feasibility of using geothermal energy to heat greenhouses.
3. Determine if any existing greenhouse facilities in the state are candidates for conversion to geothermal energy.
4. Determine sites favorable for new greenhouse construction.

The technical feasibility is to be determined using presently available off-the-shelf equipment. The objective of the study was not to innovate a new system. It has been further decided to use as much equipment in use by greenhouse growers as possible. Thus there would be less reluctance on the part of growers to use the geothermal energy.

The economic feasibility is to be established using standard estimating methods. References (1) and (2) are typical.

SYSTEMS

PRESENT SYSTEMS

The greenhouse installations in New Mexico at present use natural gas or propane for heating in winter. The most common system, generally in smaller greenhouses, consists of natural gas or propane fired unit heaters distributed in the greenhouse to provide uniform heat. The unit heaters are sometimes integrated into the greenhouse ventilation system. In this system, usually in larger greenhouses, the unit heaters are located at one end of the greenhouse and the heat is distributed to the greenhouse through perforated polyethelene tubes. The heating system used in larger greenhouses consists of a natural gas or propane fired boiler producing steam or hot water. The hot water or steam is then distributed to hot water/steam unit heaters. These are distributed in the greenhouse or integrated into the ventilation system similar to the gas fired unit heaters.

GEO THERMAL SYSTEM

The geothermal systems considered use hot water/steam unit heaters as in present systems with boilers. The boiler is replaced with a geothermal source. For the case of corrosive geothermal fluids, the boiler is replaced by a geothermal well and heat exchanger. The heat exchanger being one that can be cleaned annually in the summer when heating is unnecessary. When the geothermal fluid is not corrosive, the geothermal fluid can be pumped directly through the unit heaters in the greenhouse.

The unit heaters can be used very easily with the geothermal fluid. Manufacturers' catalogs typically give performance data for water/steam unit heaters down to 180°F (82°C); Through consultation with manufacturers performance data for even lower temperatures can be obtained. Thus the

technical feasibility is established. The primary consideration is the economic feasibility.

ECONOMIC ANALYSIS

The economic analysis consists of comparing the initial capital investment of the present gas fired heating systems and the geothermal heating system and also a comparison of the operating expenses for the two types of systems. The analysis was carried out by designing several greenhouses and estimating the system costs using references (1) and (2). The greenhouses were assumed to be in the Las Cruces Area. The systems were sized and the operating expenses were approximated using Las Cruces weather data. The analyses were done for two greenhouse constructions. Greenhouses are either glass, fiberglass or polyethelene. Some are double glazed and some growers use an insulating curtain at night. Therefore, the analysis was carried out with a heat loss of $1 \text{ BTU/HR } ^\circ\text{F Ft}^2$ of exposed surface for single glazed glass, fiber glass or polyethelene greenhouses. The analysis was also carried out with a heat loss of $.7 \text{ BTU/HR } ^\circ\text{F Ft}^2$ for double glazed glass, fiberglass or poly and single glazed houses with an insulating curtain at night.

CAPITAL INVESTMENT

The capital investment in equipment and labor for the gas fired heating system is approximately $\$.50/\text{Ft}^2$ of floor for $1 \text{ BTU/HR } ^\circ\text{F Ft}^2$ and $\$.40/\text{Ft}^2$ for $.7 \text{ BTU/HR } ^\circ\text{F Ft}^2$. The capital investment for the geothermal systems is indicated in Figure 1. This is only for the unit heaters, controls and labor for their installation. Figure 1 does not include heat exchanger costs and well drilling costs. Figure 1 thus allows one to calculate the approximated cost of unit heaters and their installation given the geothermal fluid temperature and the floor area.

Figure 2 gives the cost of the heat exchanger vs greenhouse floor area.

Figure 1 Cost of Geothermal Unit Heaters

Figure 2 Cost of Intermediate Heat Exchanger

The figure thus allows one to obtain the cost of the intermediate heat exchanger when the geothermal fluid is corrosive or could cause fouling of the unit heaters. The scatter of points at large floor areas is due to the variation in the ratio of greenhouse surface area to floor area.

The cost of the geothermal well is about \$30/Ft.; this includes the cost of the pump to remove the geothermal fluid. This value was determined from reference (3) and private communications.

OPERATING EXPENSES

The operating expenses consist of the cost of gas, electricity for the gas units and electricity for the geothermal units.

The operating expenses are based on having the greenhouse located in Las Cruces, i.e. Southern New Mexico, and having a 60°F inside temperature maintained at night and a 75°F temperature maintained during the day.

The gas used, in MCF, and electricity in KWH, per heating season is .20MCF and .22KWH per square foot of greenhouse floor area for a heat loss of 1 BTU/Hr °F Ft². For .7 BTU/HR °F Ft², the gas and electricity used are .4 MCF and .11 KWH per square foot of greenhouse floor area.

The operating costs for the geothermal units are primarily for fans in the unit heaters, circulating the fluid through the unit heaters, pumping and reinjecting the geothermal fluid and for the cost of the geothermal fluid. Figure 3 gives the electrical costs for circulating the fluid through the unit heaters and for unit heater fan power.

The electrical power to pump the geothermal fluid out of the well is 6.58×10^{-6}

Figure 3 Electrical Use by Geothermal Unit Heaters

KWH/Ft-Ft² and 4.61×10^{-6} KWH/Ft-Ft² for the greenhouses with 1 BTU/HR°F Ft² and .7 BTU/HR °F Ft² respectively. These numbers will also be used for the reinjection cost. This completes the analysis. The analysis is based on the greenhouse floor area and not on the greenhouse surface area. Thus, the figures given are for an average ratio of surface area to floor area. If one were estimating a greenhouse with a large surface to floor area, i.e. a long narrow greenhouse, the cost would be underestimated, and for a greenhouse with a small surface to floor area ratio, i.e. a square greenhouse, the cost will be overestimated using the values given.

EXAMPLE

Estimate a 20000 square foot greenhouse and compare it to a gas heated greenhouse of the same size. Assume natural gas is available at 2.75/MCF and electricity is \$.05/KWH.

Capital investment for the gas fired greenhouse is

$$$.5/\text{Ft}^2 \times 20000 \text{ Ft}^2 = \$10000$$

for a single glazed greenhouse, heat loss of 1 BTU/HR °F Ft², and

$$$.4/\text{Ft}^2 \times 20000 \text{ Ft}^2 = \$8000$$

for a double glazed greenhouse, heat loss of
.7 BTU/HR °F Ft².

The operating expenses for the gas heated greenhouse are

$$.20\text{MCF}/\text{Ft}^2 \times \$2.75/\text{MCF} \times 20000 \text{ Ft}^2 = \$11,000$$

$$\text{and } .22\text{KWH}/\text{Ft}^2 \times \$.05/\text{KWH} \times 20000 \text{ Ft}^2 = \$220$$

For the single glazed greenhouse and

$$.14\text{MCF}/\text{Ft}^2 \times 2.75/\text{MCF} \times 20000 \text{ Ft}^2 = \$7700$$

$$.11\text{KWH}/\text{Ft}^2 \times .05/\text{KWH} \times 20000 \text{ Ft}^2 = \$110$$

For the double glazed greenhouse.

Assume maintenance is 5% of initial cost of equipment, thus the single glazed

greenhouse maintenance cost is \$500/yr and the double glazed greenhouse maintenance cost is \$400/yr.

The total operating expense per year for the single glazed greenhouse is \$11720 and the double glazed greenhouse is \$8210.

For the geothermal greenhouse, assume the geothermal fluid is 180°F, is free and is available at a depth of 200 feet. Assume reinjection is unnecessary and the fluid is not corrosive. From Figure 1, the cost of unit heaters is $\$.7/\text{Ft}^2 \times 20000 \text{ Ft}^2 = \$14000$ for the single glazed greenhouse and $\$.59/\text{Ft}^2 \times 20000 \text{ Ft}^2 = \$11800$ for the double glazed greenhouse. The geothermal well cost is

$$\$30./\text{Ft} \times 200 \text{ Ft} = \$6000$$

The capital investment required is thus, for a single glazed house, \$20,000 and for a double glazed house, \$17,800. The operating expenses for the geothermal greenhouse consist of electrical energy for pumps and fans and maintenance. For Figure 3, the electrical energy for the circulating pump and fans is for the single, glazed greenhouse

$$.23\text{KWH}/\text{Ft}^2 \times .05/\text{KWH} \times 20000 \text{ Ft}^2 = \$230$$

and for the double glazed greenhouse

$$.16\text{KWH}/\text{Ft}^2 \times .05/\text{KWH} \times 20000 \text{ Ft}^2 = \$160.$$

The pumping cost is

$$6.58 \times 10^{-6} \text{KWH}/\text{Ft}^2 \times .05/\text{KWH} \times 200 \text{ Ft} \times 20000 \text{ Ft}^2 = \$1.3$$

for the single glazed greenhouse and

$$4.61 \times 10^{-6} \text{KWH}/\text{Ft}-\text{Ft}^2 \times .05/\text{KWH} \times 200\text{Ft} \times 20000 \text{ Ft}^2 = \$.92$$

for the double glazed greenhouse. Assume again maintenance costs are 5% of the initial capital investment. Thus the maintenance cost is \$1000/yr for the single glazed greenhouse and \$890 for the double glazed greenhouse.

The total yearly operating expenses are \$1231.3 for the single glazed greenhouse and \$1050.9 for the double glazed greenhouse.

TABLE 1

	Geothermal Heat Glazing		Gas Heat Glazing	
	Single \$20,000	Double \$17,800	Single \$10,000	Double \$8,000
Cap. Inv.				
Operating Expenses	1,231.3	1,050.9	11,720	8,210

From Table 1 we see that the capital investment required for the geothermal heat is approximately double that of gas, but the difference will be returned in the first year of operation in operating expenses.

SITES SUITABLE FOR CONVERSION TO GEOTHERMAL HEATING

The primary requisite for an existing greenhouse to be suitable for conversion to geothermal heating is its proximity to a geothermal source. Since we are considering low temperature sources, piping the geothermal fluid any distance is impractical because of the losses incurred. Thus, the conclusion is that none of the existing greenhouses in the state are suitable for conversion to geothermal heat. A list of existing large greenhouse operations in the state is given in the appendix. The geothermal energy heating is thus suitable for new greenhouse construction only.

SITES FOR NEW GREENHOUSE CONSTRUCTION

Since there are no existing greenhouse operations suitable for conversion to geothermal heating, the primary emphasis is on new greenhouse siting. The greenhouse, to minimize losses, has to be located in close proximity, i.e. within a few hundred feet, of the geothermal source.

Another consideration is that of a market for the greenhouse crop.

A small greenhouse operation would want to be located near a population center, i.e., Albuquerque, Santa Fe and Los Alamos or Farmington or Las Cruces and Alamogordo, thus ensuring a market for the crop. A larger operation would want to be near a major highway, i.e., I10, I25, or I40, for transportation to the markets outside the state.

The following, taken from reference (4) are likely choices for new greenhouse sites. The thermal areas in the middle and lower Rio Grande basin are ideally located for transportation, they are all very close to I25. Of these, the Truth or Consequences thermal area and the Radium Springs Thermal area are the most promising. The Socorro thermal area and Las Alturas Estates Subdivision may possibly be suitable. Their temperature and flow rates would have to be determined more exactly.

The thermal area of the Animas Valley is by far the most promising area for new greenhouse construction. The temperatures attainable and its proximity to I10 make the area ideal for establishment of a large scale greenhouse operation.

Other possible sites are the Faywood Hot Spring between Silver City and Deming, the Montezuma Hot Springs in the Pecos River basin near Las Vegas.

The remaining thermal areas in reference (4) are of either small extent or too remote to be considered.

The areas mentioned would have to be investigated thoroughly before a greenhouse is constructed.

CONCLUSIONS

The heating of greenhouses using geothermal energy is technically feasible using off-the-shelf readily available hardware. The geothermal systems are generally very capital intensive. Innovation, as in reference (5) may reduce the capital intensiveness of these systems. Because of considerations of depth to geothermal fluid, quality of geothermal fluid and cost of geothermal heat, each site has to be evaluated separately on an economic basis. In general, if the cost of geothermal heat is the same on a BTU/\$ basis as other energy, geothermal heating is not economical because of the capital investment required. If the geothermal heat is "Free" then it is very attractive economically.

 

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APPENDIX

List of Existing Large Greenhouse Operations in New Mexico

(Compilations by D.J. Cotter)

1. Sandyland - Mesilla Park, New Mexico 254,000 Sq. Ft.
2. Corrales Garden - Albuquerque, New Mexico 100,00 Sq. Ft.
3. El Cid Greenhouse - Tome, New Mexico 80,000 Sq. Ft.
4. Kent Deputy Greenhouse - New Mexico 20,000 Sq. Ft.
5. Robert Gardner - Anthony, New Mexico 10,000 Sq. Ft.
6. Hanway - Hatch, New Mexico 12,000 Sq. Ft.
7. Harris Nursery - New Mexico 15,000 Sq. Ft.
8. Eumie - New Mexico 5,000 Sq. Ft.
9. Clayton Slatting - Roswell, New Mexico 6,000 Sq. Ft.
10. Burgett Floral - Mayhill and Alamogordo, New Mexico 250,000 Sq. Ft.
11. Carpenter Nursery - Roswell, New Mexico