

ECONOMIC FEASIBILITY OF UTILIZING WASTE-WATER HEAT IN COMMERCIAL GREENHOUSES IN NORTH DAKOTA

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A large percentage of the fresh vegetables and floral products purchased in North Dakota are imported into the state. Dramatic increases in energy and transportation costs in recent years have resulted in large price increases for fresh vegetables and floral products at the retail level. These changes created a need to assess alternative strategies in the production of horticultural commodities for North Dakota consumption.

The Department of Agricultural Economics recently completed an economic feasibility study of a two-acre greenhouse facility which would utilize waste-water heat from a coal-fired electrical generating plant in North Dakota. The study had three major objectives: (1) to identify present production and consumption markets for commodities grown under greenhouse conditions and project market requirements of relevant commodities to 1990; (2) to identify capital investment and operating costs for a North Dakota plant location; and (3) to analyze the competitive position of a North Dakota based greenhouse.

Numerous commodities were defined as suitable for greenhouse production in North Dakota, including fresh tomatoes, leaf lettuce, and cucumbers; cut roses, carnations, and chrysanthemums; potted chrysanthemums, geraniums, hydrangeas, lilies, and poinsettias; six flowering and foliar bedding plants; and tomato and pepper vegetable bedding plants.

Marketing Channels

Cut flowers account for almost 50 percent of the wholesale value of the total floricultural crop in the United States. The five major cut flower crops — roses, standard chrysanthemums, pompon chrysanthemums, carnations, and gladioli — make up approximately 80 percent of the wholesale value of all cut flower crops produced in the United States (Sullivan et al., 1980).

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Historically, cut flowers have been sold by full-service retail florists. They purchase flowers from wholesalers, who in turn purchase them from growers. In some cases, a firm is vertically integrated and performs growing, wholesaling and retailing functions. Most of the retailer's business is in the sale of cut flowers for special occasions and holidays. A relatively recent development in retailing cut flowers is the mass market comprised of supermarkets, large discount stores, etc. Customer purchases at these establishments generally are spontaneous so prices must be lower than at full-service florists.

Foliage, or green plants, has increased in importance during the past decade with over 1,000 different foliage plant types currently being sold (Larson, 1980). Foliage plants are produced in areas where heat is required in greenhouses, especially in highly populated areas. Hanging basket plants, which are expensive to transport, have become an important crop in northern areas (Nelson, 1977). The mass market is emerging as a dominant retail source of foliage plants. As large chain stores command more of the market in the future, relatively large, dependable growers will be required to service the mass market.

Potted flowering plants are second only to cut flowers in importance as an ornamental crop. Several kinds of flowering plants are grown only for special holidays, such as poinsettias for Christmas. Others, such as chrysanthemums (mums), generally are grown for sale the year around.

The production of flowering plants requires a high level of management expertise because of the very seasonal demand that exists, especially for lilies and poinsettias. Flowering plants are generally grown closer to areas of consumption than cut flowers because of the difficulty in packaging and relatively heavy weight.

Growers of flowering plants generally sell directly to retailers. Flowering plants generally are available in-season and on a year-around basis at retail florist stores. Mass retailers are important outlets during holiday periods.

Bedding plants are produced for spring sales to consumers for flower beds and vegetable gardens. Fifty plant species or more are grown, ranging from vegetables such as tomato, pepper, and cabbage to

flowers such as petunia, marigold and impatiens (Nelson, 1977).

The production of bedding plants is more regionalized than other floriculture crops for several reasons. The varieties must be adaptable to climatic conditions in the area where they are sold since these plants will be transplanted to an outdoor environment. Furthermore, they are bulky and somewhat difficult to transport. Bedding plants often are marketed directly by growers to retailers.

The greenhouse vegetable industry in the U.S. is relatively small when compared to floriculture. Both climate and distance to market provide economic constraints to location of vegetable production. Technological advances in vegetable handling, transportation equipment and improved highway systems along with significantly higher heating costs have reduced locational advantages near to population (Cravens, 1977). The marketing of greenhouse vegetables may be as simple as direct to consumers or very complex involving several wholesaling functions.

Seasonality of Prices

Prices for three vegetables — tomatoes, cucumbers and lettuce — were analyzed to determine seasonal patterns. Monthly prices for these commodities were analyzed for the 11-year period 1970-1980. The reported data represent sales on the Minneapolis Wholesale Produce Market in less than carlot quantities delivered to the retailer (Federal-State, Minn., 1971-1981).

Tomato prices were highest in January, April and June and lowest in September, October and November. July and September tend to be the months with low leaf lettuce prices, while March tends to have the highest prices. Cucumber prices were lowest in August and September and highest in March and April.

The price behavior patterns of six cut flowers — tea roses, sweetheart roses, standard carnations, miniature carnations, pompon chrysanthemums and extra large chrysanthemums — were analyzed to determine seasonal patterns. Monthly prices for these commodities were analyzed for the eight-year period 1973-1980 (Federal-State, Minn., 1974-1981). An analysis of prices was not conducted for potted and bedding plants as these normally are produced seasonally.

Tea and sweetheart roses have immense popularity at least two days per year — Valentine's and Mother's Day. Prices for tea and sweetheart roses were highest in February and May, dropping off significantly from June through November. Similar price patterns were found for carnations and chrysanthemums.

Greenhouse Industry in North Dakota

North Dakota had only 67 greenhouses in operation in 1980 (N.D. Dept. of Agriculture, n.d.) with the majority utilized for bedding plant production. Thirty-six

greenhouse operators in North Dakota were surveyed in the spring of 1981 to obtain information on size of operations, types of products grown, marketing channels and prices of products grown. Thirty-four of the 36 greenhouse operators interviewed grew bedding plants, 13 grew potted plants, three grew vegetables and two grew cut flowers. Cut flower growers operated greenhouses year-around, followed by vegetable growers (9.7 months per year), potted plant growers (7 months per year), and bedding plant growers (5.5 months per year). Cut flower growers were by far the largest, operating 6.5 greenhouses with an average total capacity of 30,000 square feet for the total operation. Vegetable growers were in business the shortest amount of time (four years). Natural gas was the primary fuel source used by 17 growers, followed by propane, coal and fuel oil. Natural gas and propane were the principal secondary heat sources utilized.

Caution must be taken when interpreting the results. Some double counting exists since some operators were involved in the production of more than one type of product.

Twenty-two of the growers indicated they foresaw no changes in their future production and marketing practices, while seven growers planned to expand their production facilities. Eighteen growers indicated that the major problem facing the industry was rising fuel costs, while five growers expressed concern about poor sales. Vegetable growers indicated that retailers were their primary outlet, while cut flower, bedding plant and potted plant growers relied upon direct sales to consumers. In general, vegetable producers supplied the local area, while cut flower growers supplied retailers and consumers up to 100 miles away.

Petunias and geraniums constituted the majority of production by those North Dakota greenhouse operators surveyed with producers growing an average of 5,616 and 5,235 6-packs, respectively, in 1981. Chrysanthemums and poinsettias were the most popular potted plants grown by North Dakota producers in 1981 with average production levels of 2,960 and 2,735 pots, respectively.

Growers were asked to indicate prices charged to wholesalers, retailers and producers. Growers charged an average of \$.88 per pound for tomatoes to wholesalers and \$.89 per pound to retailers and consumers. Prices charged for bedding plants to retailers ranged from a high of \$1.03 per 6-pack for geraniums to a low of \$.71 per 6-pack for tomatoes. Prices to consumers ranged from a high of \$1.50 per 6-pack for geraniums to \$.84 per 6-pack for coleus.

The largest differential between prices to retailers and consumers occurred for potted plants. Retailers were charged an average of \$5.25 per pot for chrysanthemums while consumers were charged an average of \$11.50 per pot. Similar price differentials were noted for geraniums, lilies and poinsettias.

Food Wholesale Industry in North Dakota

Sixteen food wholesalers in North Dakota were surveyed in the summer of 1981 to obtain information on marketing channels, volume of products and prices of fresh tomatoes, leaf lettuce and cucumbers supplied to retailers, hotels-motels, institutions and restaurants.

Food wholesalers indicated average weekly volumes of 5,108 pounds of tomatoes, 734 bunches of leaf lettuce and 68 bushels of cucumbers. Food wholesalers relied on Florida for their supply of tomatoes nearly half the year. Wholesalers utilized Mexican-grown tomatoes only 2.6 months per year. California was the main source of supply of leaf lettuce, accounting for 10.5 month's supply per year. Cucumbers were purchased from Florida producers 4.7 months per year, while wholesalers relied on local outdoor production 2.9 months per year.

Over half of the tomatoes were purchased by the hotel, restaurant and institutional (HRI) sector, while the remaining portion was utilized by the retail grocery store sector. Leaf lettuce was utilized almost exclusively by the HRI sector, while three-fourths of the cucumbers were purchased by the retail grocery store sector.

Wholesalers paid an average of \$.51 per pound for tomatoes in 1980, \$5.94 per carton for leaf lettuce, and \$14.70 per bushel for cucumbers. Wholesalers indicated that 50 percent of their tomatoes, leaf lettuce and cucumbers was being shipped an average of 26 to 100 miles, while 40 percent was shipped within 25 miles and 10 percent was shipped over 100 miles.

Fifteen of 16 wholesalers indicated they would be interested in purchasing locally grown vine-ripened produce. Over 87 percent of the respondents indicated higher quality would be the first reason to change or add suppliers. A guaranteed supply was ranked as the second most important factor by 73 percent of the respondents, followed by standardization (70 percent of respondents).

Consumption Estimates

Consumption of horticultural commodities was determined for cut flowers, potted plants and bedding plants. Per capita consumption of fresh tomatoes, leaf lettuce and cucumbers in North Dakota was projected to increase from 8.68, 2.03, and 4.01 pounds in 1981 to 9.03, 2.25, and 4.76 pounds in 1990, respectively.

Per capita consumption of carnations was projected to increase from 4.44 blooms in 1980 to 6.23 blooms in 1990. Per capita consumption of standard chrysanthemums was estimated to decline from .53 blooms in 1980 to .40 blooms in 1990, while per capita consumption of pompon chrysanthemums was projected to increase from 1.98 bunches in 1980 to 2.87 bunches by 1990. Per capita consumption of roses remained relatively constant between 1971 and 1980 at 2.10 blooms and was projected to remain at 2.08 blooms through 1990.

Potted chrysanthemum consumption was projected to increase from .128 pots in 1980 to .177 pots per capita in 1990. Projected per capita consumption of geraniums, hydrangeas, lilies, and poinsettias for 1981 through 1990 was .220, .013, .033, and .095 pots, respectively.

Per capita consumption of flowering and foliar bedding plants was estimated at .109 flats and .050 flats for vegetable bedding plants for the years 1981 through 1990. Total consumption of all cut flowers, potted plants, and bedding plants in North Dakota was projected to increase between 1981 and 1990, except for standard chrysanthemums which were projected to decline by 23 percent over that time period. Major increases were noted in cut carnations and pompon chrysanthemums.

Model Greenhouse Design

Preliminary engineering estimates and designs were prepared for a simulated two-acre greenhouse structure and were used to establish cost requirements for a site located near Velva, North Dakota (Ashley, 1980). A pipeline network was designed which was capable of moving warm waste water from a coal-fired electrical generating plant to the simulated two-acre greenhouse. The simulated greenhouse was designed to utilize this warm waste water as its primary heat source.

A two-acre production facility was designed as representative of what a prospective commercial grower would consider as an economically viable unit. Each of the two greenhouses had an outside dimension of 144 feet by 288 feet, or 41,472 square feet each, and are connected by a covered walkway. The service building, connected by another covered walkway, contained 4,800 square feet.

Construction costs for the greenhouse were calculated for the following design. The greenhouse would be constructed in a rigid frame, gutter connected style with a free span width of 36 feet. It would be covered with double polyethylene with the potential to change to a rigid double skin in the future. The sidewalls and endwalls would be covered similarly and gutter height would be 10 feet.

The greenhouse site would be serviced with warm water for heating and would have a septic tank and drainfield for sewage, a well for irrigation and potable water, underground electric service and propane tanks for supplemental fuel supply. The site would be graded level and a compacted base established for the access roads and main entrance area parking. Several systems are included in the greenhouse: the greenhouse structure, heating system, back-up heating system, ventilation and evaporative cooling, electrical system and controls, domestic water and irrigation, service building and other optional items.

Construction Cost Estimates

The estimated capital cost for the two-acre greenhouse unit was \$919,500, with an additional \$166,800 required for the pipeline system. The greenhouse structure was bid on the basis of vendor-supplied labor for erection. This portion of the bid is \$47,692 for one acre or about 30 percent of the cost of the greenhouse itself. Labor for all the other work required would average about 40 percent of the total cost or about \$240,000 for a two-acre greenhouse. Since many commercial growers build portions of their greenhouses and related facilities themselves, it is possible that the actual cost to the grower-owner might be less than the present estimate due to the substitution of lower cost labor. A precise estimate is difficult, but a savings of \$100,000 to \$150,000 for a two-acre greenhouse is reasonable.

Cost and Benefit of Using Waste Heat

Waste heat cannot be considered free because there is an incremental cost associated with the delivery and use of waste heat. The capital cost of the delivery system is about \$83,400 per acre of greenhouse serviced. This cost must be paid by the heat user, either as a one-time hook-up fee or amortized at prevailing interest rates over several years.

The incremental operating cost associated with waste heat use is comprised of extra electric power costs and the cost of supplemental fuel. The benefit of using waste heat is the difference between the total cost of using waste heat as opposed to any other fuel that is readily available and practical for the grower to use.

The costs of heating a two-acre greenhouse in North Dakota with natural gas, No. 2 oil and waste heat were compared. The use of waste heat could result in annual savings of \$400 to \$95,800 per year compared to natural gas and fuel oil, respectively. Natural gas prices in the area are artificially low at present. If both gas and oil prices increase in the future, the benefit of waste heat will be more dramatic.

Estimated Costs and Returns From A Simulated Two-Acre Greenhouse Using Waste Heat

Operating costs, expected returns, and return on investment were estimated for a two-acre greenhouse. Variable production costs were estimated specifically for each crop. Annual fixed costs were estimated at \$251,800 for a two-acre greenhouse.

Up to 25 percent of the total North Dakota market would be required before the greenhouse would return a profit. A return on investment of .33 percent would be realized at a 25 percent market share limit with total cost and revenues of \$608,042 and \$611,073, respectively. A

profit and return on investment of \$40,254 and 4.38 percent, respectively, would accrue to the greenhouse if up to 33 percent of the North Dakota market could be captured.

The greenhouse would not be profitable if only vegetables were produced. Up to 33 percent of the North Dakota market would have to be captured for the greenhouse to be profitable if only cut flowers, potted plants, and bedding plants were produced. If a grower constructed the greenhouse utilizing local labor, the greenhouse would become profitable at the 20 percent market share limit.

The estimated returns on investment for the two-acre greenhouse are relatively low when compared to other potential investments. Possibly the greatest potential exists for greenhouse firms currently operating in North Dakota to expand or relocate by building facilities near a coal-fired electrical generating plant. These firms already have an established share of the market and are well aware of the potential for increasing sales of specific crops. This study will be of interest to these firms for initial construction and operating cost information. However, they should consider performing their own price and production estimates based on conditions that actually exist for their firm.

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