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HOW WILL THE GREENHOUSE INDUSTRY UTILIZE WASTE HEAT?

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ABSTRACT

Recent regulatory and economic change encourages waste heat use in the northern United States. In this article, the value of that form of energy to growers of greenhouse crops is assessed. It is found that production of rooted floricultural crops is likely to be the dominant activity at facilities supplied with waste heat. Waste heat utilization is unlikely to cause interregional relocation of vegetable production in the U.S.

KEY TERMS: Waste Heat Utilization; Greenhouse Industry

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INTRODUCTION

Until fifteen years ago, incentives to reduce or to capture waste heat were weak. Because energy prices were low, private benefits of improved energy efficiency were likewise low. In addition, few industries faced regulatory controls on thermal pollution. Accordingly, an individual firm rarely incurred costs in order to keep its waste heat from driving up temperatures in a waterway or an airshed.

Since the late 1960's, economic and regulatory change have had a major impact on the "market" for waste heat. Both supply and demand in that market increased as more stringent environmental laws were promulgated. Most recently constructed power plants, for instance, have been compelled to install a "closed loop" water cooling system. At plants employing such a system, warm water has been made available for alternative uses. Also, by limiting the use of conventional fuels (especially coal), air pollution controls have increased demand for waste heat.

Increased prices for conventional fuels stimulates a search for more energy efficient industrial processes. As that search results in greater energy conservation, the supply of waste heat is reduced. However, increased prices for coal, natural gas, and other substitutes for waste heat increases demand for the latter commodity. Overall, rising conventional fuel prices probably promotes waste heat utilization.

Agriculture figures prominently in efforts to utilize waste heat. Space heating, crop drying, and water heating have been identified as uses of waste heat available at power plants, refineries, pumping stations, and other industrial facilities (1). In particular, the greenhouse industry seems likely to become a major agricultural user of waste heat. Since the 1973-74 run up in energy prices, researchers at agricultural experiment stations across the northern United States have been studying ways to reduce the energy intensity of greenhouse production of vegetables and horticultural crops (2). However, in spite of their findings and in spite of the results of research and innovation in Europe and Japan, expenditures on fuel continue to account for a major share of greenhouse crop production costs in this country.

Coincident with their desire to reduce fuel bills, greenhouse growers in the Midwest and Northeast are interested in waste heat utilization as a means to regain a comparative advantage in the supply of tomatoes, lettuce, flowers, and other crops to the populous northeastern quadrant of the country. Since the late 1950's, imports of produce and horticultural crops into that region have increased, largely at the expense of local production. It is conceivable that, if waste heat were priced low enough, Midwestern and Northeastern greenhouse growers, who are just beginning to use that energy resource (3), could compete with producers located in warmer parts of the United States and in foreign countries.

Insights into how the greenhouse industry in the Midwest and Northeast might use cheaply priced waste heat were gained recently by researchers evaluating potential demand for space in a proposed agribusiness park in southern Ohio (4). That park would be heated primarily with warm water generated at an adjacent industrial facility.[1] Reported in this paper are the study's principal findings. First, the conceptual approach used in the research is outlined. Next, estimates of the costs of growing vegetable and horticultural crops in a greenhouse under different assumptions regarding the price of waste heat are reported. Those costs are compared to current crop prices. Finally, conclusions drawn from this study about how waste heat utilization will affect the greenhouse industry are offered.

CONCEPTUAL ISSUES

As a rule, economic studies of greenhouse heating systems that employ alternative fuels use the same methodological approach. Capital and operating costs associated with conventional space heating are compared with capital and operating costs of alternative energy systems. Because solar energy, waste heat, and other alternative energy systems typically require specialized equipment as well as back-up heating units that run on fossil fuels, their capital costs tend to be relatively high. Hence, the economic feasibility of switching to alternative energy depends both on reductions in operating costs and on the decision maker's discount rate and time horizon (5,6).

Some analyses that rest on a comparison of an alternative energy system with a conventional system are biased toward the former because they overestimate fossil fuel use in a modern, conventionally heated facility. Insulating, installing heat curtains, and implementing other energy conservation practices reduce a greenhouse operation's energy inputs considerably at a relatively low cost. Studies that ignore opportunities for energy conservation, which are being taken advantage of by many firms in the industry, implicitly overestimate the value to a greenhouse firm of utilizing alternative enrgy.[2]

Failing to describe heating options accurately does not in and of itself invalidate the general approach of comparing conventional with alternative energy. Friday, Stipanuk, and White, however, argue that this approach yields correct insights only if the greenhouse industry is in long run equilibrium, which it is not. As they point out, production in midwestern and northeastern greenhouses of vegetables and many other categories of crops has been declining for many years (7). Cravens predicts that, unless greenhouse growers can differentiate their relatively high quality products, vegetable and horticultural crop production will become increasingly concentrated in warmer parts of this country as well as in Latin America (8).

While production of crops in greenhouses is declining, showing that utilization of waste heat, solar energy, or some other alternative energy source is cheaper than burning fossil fuels does not prove that the industry will switch to alternative energy. Friday, Stipanuk, and White argue that, since disinvestment is occurring in the greenhouse industry, the switch will be made only if the average total costs of producing vegetables or other crops in a greenhouse where alternative energy is utilized are less than average variable costs in a conventionally heated facility (7).

This test of the economic feasibility of alternative energy systems is too stringent, however. Standard Marshallian theory of long run equilibrium suggests that waste heat utilization would be feasible if average total costs at a facility with the alternative energy system are lower than prices received for that facility's products. The latter test for feasibility is an improvement on the test proposed by Friday, Stipanuk, and White (7) because it allows for the possibility that disinvestment in conventionally heated greenhouses and investment in facilities heated with alternative energy can occur simultaneously.

Comparing average total costs with market prices yields useful information about long run equilibrium in the greenhouse industry. Because markets for vegetable and floricultural crops are highly competitive, prices observed in the Midwest and Northeast closely approximate the sum of marginal costs of producing those commodities in other regions or countries plus transportation expenses. In this study, judgments regarding the feasibility of utilizing waste heat are based on comparisons of prices and average total costs.

ANALYSIS OF GREENHOUSE CROP PRODUCTION COSTS

As part of the above-mentioned study of potential demand for space in a proposed agribusiness park into which waste heat would be channeled, analysis of the costs of producing a variety of greenhouse crops under different assumptions regarding the price of waste heat was conducted (4). In this section are reported the results of production cost research for two crops: tomatoes and potted chrysanthemums (Tables 1 through 5).

Growing tomatoes was found to be significantly more profitable than raising other types of produce, such as cucumbers and lettuce. Hence, results of economic analysis of tomato production are reported here. Because imports account for a major share of cut flower supply in this country, no analysis of the cost of growing that product was undertaken. By contrast, domestic producers of flowering potted plants, foliage, and bedding plants are protected from foreign competition by Quarantine 37, which prohibits the importation of any plant rooted in a medium that contains soil. Because potted chrysanthemums lend themselves to automated production and since demand for that plant is relatively large, the results of economic analysis of potted chrysnathemum production are reported in this paper.

Budgets were developed to estimate average total costs (ATC) of production. They were built on two assumptions regarding tomato and potted chrysanthemum production functions: (a) constant returns to scale and (b) no substitution between nonenergy inputs and energy inputs. This first assumption is not a serious abstraction from reality in the greenhouse industry. All major scale economies in the production of the two crops are captured in a five-acre greenhouse, the size used to model capital costs in this study. The second assumption could conceivably bias the results of the research reported here. Saying that energy cannot be substituted for capital and other inputs leads to underestimation of the impacts on ATC of a reduction in the price of waste heat. It was found, however, that no major change in factor proportions would be observed in the greenhouse industry even if the price of waste heat were significantly below the prices of alternative forms of energy (9).

Information about input-output relationships for the two crops were obtained from previously published budgets (10, 11) and from interviews with growers and individuals familiar with that industry (Tables 1 through 4). Assumptions are summarized below.

- Annual marketable yields/acre for the tomato and chrysanthemum enterprises were 200,000 pounds and 170,000 6 1/2 inch pots, respectively. Two crops of tomatoes were budgeted, one in the Spring and one in the Fall. Chrysanthemums were planted and harvested on two-week intervals. The average time span between planting and marketing was 12 weeks. Although some firms in Ohio produce at a higher annual rate, the assumed yields exceed most of the state's producers' actual yields.

- Construction costs for a turn-key tomato production facility were assumed to equal $6.00/square foot (all values are in 1984 dollars). This cost reflects a double-layer of polyethelyne covering and assumes that tomatoes are grown in soil. The capital budget in the original study, at about $8.50/square foot (4), also called for a back-up heating system, heat curtains, and growing tomatoes in "bag culture".
- Construction costs for a turn-key chrysanthemum production facility, $13.15/square foot, reflect a more sophisticated building and set of equipment. The chrysanthemum facility would have glass covering, porous concrete floors, heat curtains, movable benches, root zone heating, back-up heating, and other physical capital needed for modern floricultural production.
- It was assumed that a 10 percent investment tax credit would be taken and that all buildings would be fully depreciated over 15 years.
- Annual interest payments were calculated using a real interest rate of 7 percent. Budgets were calculated using higher interest rates as well.
- Labor inputs consisted of a manager, assistant manager, permanent staff, and a harvest crew. Salaries plus fringe benefits for the former were $20,000 and $14,600, respectively. Hourly wages for staff and crew ranged

from $4.00 to $5.00 (including vacation and unemployment insurance).

- Assuming no deliveries of waste heat, it would cost $55,000/acre to heat the tomato facility (no heat curtains) and about $49,000/acre to heat the chrysanthemum facility using natural gas. These reflect current expenses of heating a greenhouse in Ohio.

To determine how the availability of cheaply priced waste heat would affect greenhouse crops production costs, ATC was estimated assuming that a firm's waste heat bill equalled varying percentages of total expenditures on natural gas at a conventionally heated greenhouse. Reported in Table 5 are estimates of the costs of producing the two crops under different assumptions regarding heating costs (which are expressed as varying percentages of the current expense of heating with natural gas). These estimates were compared to current prices received by greenhouse growers for the two commodities (Table 5). After falling during the past ten to fifteen years, real tomato prices have stablized since 1982 at a range of $0.60 to $0.85/pound (producer level). Producer chrysanthemum prices have ranged from $2.75 to $3.75 the past several years.[3]

In spite of the limitations on this study imposed by characterizing horticultural crop production as a fixed coefficient function, the estimates of ATC yield interesting insights. Even if waste heat were offered at 20 percent of the price of natural gas, greenhouse tomato production (even in a low cost facility) would not be economical. Normal profits would be earned only if yields were 25 percent higher than the yields assumed in this study, if real interest rates fell to 5 percent and if the price of waste heat dropped below 20 percent of the price of natural gas. By contrast, greenhouse producers of potted chrysanthemums can cover all costs at current average producer prices even if waste heat is not priced at a discount (Table 5).

These results illustrate that comparing costs of production at a facility where waste heat or some other alternative heat source is used with costs of production at a conventionally heated greenhouse yields limited insights. Only where market conditions are favorable, which is the case for potted chrysanthemum producers but not for tomato growers, is investment in an alternative energy system warranted.

CONCLUSIONS

The results of economic analyses reported above suggest that production of rooted floricultural crops will be the dominant activity in greenhouses located in midwestern and northeastern states where waste heat is utilized. Unless (a) the price of waste heat is well below the prices of conventional fuel substitutes, (b) greenhouse construction and equipment costs are sharply reduced, (c) vegetable prices rise considerably, and (d) yields increase substantially, greenhouse vegetable production will remain economically infeasible. By contrast, no discount in energy prices is needed to make waste heat utilization feasible for growers of rooted floricultural crops.

An implication of this study's results is that markets for some rooted floricultural crops are not in long run equilibrium. The estimate of ATC of growing potted chrysanthemums in a conventionally heated greenhouse is somewhat lower than the producer price of that commodity. As supply of potted chrysanthemums increases in response to the difference between price and ATC, the scarcity rents collected by providers and users of waste heat will fall.

These conclusions are corroborated by actual industry performance. Grower experience suggests that cheaply priced waste heat does not compensate for the inability of the greenhouse vegetable industry in the northeastern quadrant of this country to compete with growers in Latin America and in warmer parts of the United States. None of the firms in the Midwest and the Northeast that grow vegetables using waste heat report that revenues from crop sales exceed costs of production. Among those firms is one located adjacent to a power plant in Pennsylvania that pays a very low price for waste heat and that receives substantially higher prices for its produce than do other growers.

The most telling evidence that the Midwest and Northeast do not have a comparative advantage in producing vegetables for the Winter and early Spring markets is obtained from interpretation of U.S. Census of Agriculture data. That data show, for example, that the decline in Ohio's greenhouse vegetable industry was well underway during the 1960's, while energy prices were low (12). Construction of the interstate highway system greatly reduced the cost of bringing produce to the Midwest and Northeast from Florida, the southwestern United States, and, more recently, from Mexico. The lower cost of field production in a warm climate far outweighs the advantage Ohio growers have in being situated close to markets, even if one assumes a major reduction in energy and greenhouse construction costs in the state.

The results of feasibility analysis for floricultural crop production are also corroborated by actual industry performance. The downward trend observed during the 1960's in Ohio's greenhouse acreage, caused by declining vegetable production, was reversed during the 1970's because of expanded floricultural crop production. That expansion has continued in the 1980's (12). This shift in supply has driven down real prices for floricultural commodities.

Waste heat utilization at greenhouses, like employment of alternative energy systems in general, remains a relatively rare phenomenon (7). Most facilities that receive waste heat are subsidized (13). Our study suggests that whether or not waste heat utilization will move from the experimental stage to general practice within the greenhouse industry will depend on what happens in markets for rooted floricultural crops. If demand for those commodities continues to grow and if the U.S. industry continues to be protected from imports, then floricultural industry use of waste heat will increase.

FOOTNOTES

1. A system of pipes and heat exchangers would transfer waste heat from a U.S. Department of Energy uranimum enrichment plant to the Piketon Agribusiness Center. The risk that greenhouse crops would be contaminated through the heating system is extremely low.
2. For example, in their comparison of solar and conventional heating of greenhouses, Dhillon and Rossi (1982) assume that no energy conservation techniques are employed in conventionally heated facilities.
3. The tomato price approximately equals average producer prices received by greenhouse growers during the Winter and Early Spring, when the greenhouse tomato crop comes on market. During the rest of the year, local field production drives down vegetable prices. The potted chrysanthemum price is an approximate average of producer prices observed throughout the year. Diversified firms target potted chrysanthemum production during periods of peak demand. By doing so, they obtain substantially higher prices for that commodity.

REFERENCES

1. Authur, D. Little, Inc., Waste Heat Utilization Handbook, report prepared for U.S. Department of Energy, 1981.

2. H.A. Poole and P.A. Gresser, "An Annotated Bibliography of Greenhouse Energy Conservation and Management" (Research Circular 262). Ohio Agricultural Research and Development Center, Wooster, 1980.

3. R.E. Friday, "The Feasibility of Using Reject Heat on a Commercial Scale," Florist Review (May, 1982), 30-6.

4. D. Southgate, R. Taylor, E. Watkins, H. Tayama, D. Hahn, S. Uchida, E. Gadomski, A. Oden, and T. Prince, "The Feasibility of Greenhouse Vegetable and Floricultural Crop Production at the Proposed Pike Country Agribusiness Park. "Report prepared for Pike County Development and Energy Management Corporation", 1984.

5. J.B. Braden, S.S. Lazarus, and P.N. Walker, "Economics of Water Blanket Technique for Greenhouse Heating," Am. J. Agr. Econ., 64 (1982) 573-7.

6. P.S. Dhillon and D. Rossi, "Economic Feasibility of Using Solar Energy in the Production of Greenhouse Tomatoes," J. NE Agr. Econ. Council, 11 (1982) 227-32.

7. R.E. Friday, D.M. Stipanuk, and G.B. White, "Greenhouse Heating Options: Can Waste Heat Compete?" Paper presented at the Third Conference on Waste Heat Management and Utilization, Miami Beach, Florida, May 11-13, 1981.

8. M.E. Cravens, "Comparison of Economics of Winter Production of Horticultural Products in Greenhouses in the U.S.A. with Outdoor Products in Areas Distant from the Market." Paper delivered at the International Symposium on Controlled Environment Agriculture, University of Arizona, Tucson, Arizona, April 7, 1977.

9. D. Southgate, S. Uchida, and E. Gadomski, "The Relationship between Price of Waste Heat and Greenhouse Industry Production Systems," Hort Science, 20 (1985).

10. R.G. Brumfield et at., "Overhead Costs of Greenhouse Firms Differentiated by Size of Firm and Market Channel" (Technical Bulletin 269). North Carolina Agricultural Research Service, Raleigh, 1982.

11. C.J. Stathacos and G.B. White, "An Economic Analysis of New York Greenhouse Enterprises," (Department of Agricultural Economics Research Paper 81-21). Cornell University Agricultural Experiment Station, Ithaca, N.Y. 1981.

12. Bureau of Census. Census of Agriculture, U.S. Department of Commerce, Washington, D.C., various years.

13. G. Davidson, President, AgrowNautics, Inc., Salisbury, Connecticut, personal interview, August, 1984.

TABLE 1.-- Capital Requirements for a Five Acre Tomato Greenhouse Facility, 1984

Item	Description	Costs per Square Foot (Dollars)	Costs per Acre (Dollars)	Costs per Five Acres (Dollars)
Land	Unimproved	0.046	2,000	10,000
Structure Costs*	Complete	6.00	261,360	1,306,800
Service Building	10,000 sq ft @ $18.89/sq ft	0.867	37,780	188,900
Cold Storage	10000 cu ft @ $3.46/cu ft	0.159	6,920	34,600
Picking Tubs	$8/tub - 375 tubs/acre.	0.069	3,000	15,000
Total Capital Cost		7.141	311,060	1,555,300
Less Credit	10% Investment Tax on depreciable items	0.710	30,906	154,530
Net Capital Cost		6.431	280,154	1,400,770

*Structure includes: double polyethylene covering, CO2 generators, heating system, cooling system, water system, and land preparation.

TABLE 2.-- Fixed, Variable, and Total Costs of Operating a Five Acre Tomato Greenhouse, 1984.

Item	Description	Costs per square Foot per Year (dollars)	Costs per Acre per Year (dollars)	Cost per Five Acres per Year (dollars)
Fixed (facility)				
Taxes		0.030	1,307	6,535
Insurance		0.130	5,663	28,315
Depreciation				
Structure	15 yr. straight line	0.400	17,424	87,120
Service Building	15 yr. straight line	0.058	2,519	12,595
Cold Storage	15 yr. straight line	0.011	461	2,305
Picking Tubs	5 yr. straight line	0.005	200	1,000
Interest Charges	7% real on $280,154/ac.	0.450	19,611	98,055
Subtotal		1.084*	47,185	235,925
Variable Overhead Costs				
Accounting		0.025	1,089	5,445
Legal		0.011	479	2,395
Office Expense		0.066	2,875	14,375
Promotion	$0.02/lb	0.066	2,875	14,375
Miscellaneous Freight Expense		0.011	479	2,395
Telephone		0.041	1,786	8,930
Business Travel		0.014	610	3,050
Dues and Subscriptions		0.016	697	3,485
Water and Sewage		0.039	1,699	8,495
Vehicle Expense		0.213	9,278	46,390
Repairs - General		0.067	2,919	14,595
Electricity		0.092	4,008	20,040
Subtotal		0.661*	28,794	143,970
Nonlabor Operating Costs				
Heat	Heat based on natural gas @ $82,056/acre/year. Heating costs were then reduced by 33% for double poly.	1.263	55,000	275,000
Fertilizer		0.092	4,000	20,000
Insect Control		0.058	2,527	12,635
Seed		0.023	1,000	5,000
Pot mix		0.016	700	3,500
Twine and Vine Clips		0.014	600	3,000
Polyethylene Replacement	Cost per roll is $288.85 for 40'x100', 6 mill plastic roll. The number of rolls needed per acre is 29. Useful live is 2 years.	0.192	8,364	41,820

Table 2 Cont.

Item	Description	Cost per square Foot per Year (dollars)	Cost per Acre per Year (dollars)	Cost per Five Acres per Year (dollars)
Greenhouse up-Keep		0.046	2,000	10,000
Packing Costs	$0.08/lb.	0.328	14,282	71,410
Subtotal		2.031*	88,473	442,365
Labor Costs				
Management Team				
Manager	Wages and benefits set at $20,000/year.	0.092	4,000	20,000
Assistant Manager	Cost based on 40 hours/ week @ 52 weeks/year for for 5 acres. Wages and benefits set at $7.00/hour or 14,560/year.	0.067	2,912	14,560
Permanent Staff and Harvest Crew				
Permanent Staff	Cost based on 2.5 people/acre @ $5.00 hr. for 40 hours/week and 52 weeks/year. Wages inclued benefits.	0.597	26,000	130,000
Harvest Cost	Cost based on 2 people/ acre for 24 weeks @ 4.00/hour for 40 hour/week. Wages included benefits.	0.176	7,680	38,400
Subtotal		0.932*	40,592	202,960
Interest on Operating Capital	Interest computed on 7% of $157,859/acre for six months	0.127*	5,525	27,625
TOTAL COSTS		4.834*	210,569	1,052,845

*Subtotals and total costs per square foot are not additive. There were determined by dividing per acre costs by 43,560.

TABLE 3.-- Capital Requirements for a Five Acre Chrysanthemum Greenhouse Facility, 1984

Item	Description	Costs per Square Foot (Dollars)	Costs per Acre (Dollars)	Costs per Five Acres (Dollars)
Land	Unimproved	0.046	2,000	10,000
Structure Costs*	Complete	13.150	572,814	2,864,070
Service Building	10,800 sq ft @ $18.89/sq ft	0.937	40,802	204,012
Cold Storage	704 cu ft @ $3.46/cu ft	0.011	487	2,436
Total Capital Cost		14.144	616,103	3,080,518
Less Credit	10% Investment Tax on depreciable items	1.420	61,410	307,052
Net Capital Cost		12.734	554,693	2,773,466

*Structure includes: glass covering, heating system, back-up heating, cooling system, water system, heat curtains, computer controls, pot/flat filling machine, rolling benches, and land preparation.

TABLE 4.-- Fixed, Variable, and Total Costs of Operating a Five Acre Chrysanthemum Greenhouse, 1984.

Item	Description	Costs per square Foot per Year (dollars)	Costs per Acre per Year (dollars)	Cost per Five Acres per Year (dollars)
Fixed (facility)				
Taxes		0.030	1,307	6,535
Insurance		0.130	5,663	28,315
Depreciation				
Structure	15 yr. straight line	0.877	38,188	190,938
Service Building	15 yr. straight line	0.062	2,720	13,600
Cold Storage	15 yr. straight line	0.001	32	162
Picking Tubs	5 yr. straight line	0.005	200	1,000
Interest Charges	7% real on $554,693/ac.	0.891	38,829	194,143
Subtotal		2.000*	86,939	434,693
Variable Overhead Costs				
Accounting & Legal		0.040	1,742	8,710
Office Expense		0.100	4,356	21,780
Promotion		0.070	3,049	15,245
Telephone		0.040	1,742	8,710
Business Travel & Vehicle		0.220	9,583	47,915
Water and Sewage		0.040	1,742	8,710
Electricity		0.090	3,920	19,600
General Repairs		0.110	4,792	23,960
Subtotal		0.710*	30,926	154,630
Nonlabor Operating Costs				
Heat	Heat based on natural gas @ $82,056/acre/year. Heating costs were then reduced by 40% for double poly.	1.130	49,234	246,170
Plant		3.560	155,074	775,370
Pot		0.500	21,780	108,900
Potting mix		0.580	25,265	126,325
Chemicals		0.500	21,780	108,900
Packaging		0.310	13,504	67,520
Subtotal		6.580*	286,637	1,433,185

Table 4 Cont.

Item	Description	Cost per square Foot per Year (dollars)	Cost per Acre per Year (dollars)	Cost per Five Acres per Year (dollars)
Labor Costs				
Management Team				
Manager	Wages and benefits set at $20,000/year.	0.092	4,000	20,000
Assistant Manager	Cost based on 40 hours/ week @ 52 weeks/year for for 5 acres. Wages and benefits set at $7.00/hour or 14,560/year.	0.067	2,912	14,560
Permanent Staff and Harvest Crew				
Permanent Staff	Cost based on 2.5 people/acre @ $5.00 for 40 hours/week and 52 weeks/year. Wages inclued benefits.	0.597	26,000	130,000
Seasonal Crew	Cost based on 2.5 people/ acre for 3 months @ 4.00/hour for 40 hour/week. Wages include benefits.	0.119	5,200	26,000
Subtotal		0.875*	38,112	190,560
Interest on Operating Capital	Interest computed on 7% of $355,675/acre fir six monthss.	0.286	12,449	62,245
TOTAL COSTS		10.447*	455,063	2,275,313

*Subtotals and total costs per square foot are not additive. There were determined by dividing per acre costs by 43,560.

TABLE 5.--Producer Prices and Average Total Costs of Producing Tomatoes and Chrysanthemums in Greenhouses, 1984.

Crop	Producer Price	Average Total Cost		
		Heating Cost as a Percentage of Current Cost of Heating with Gas-Fired Boiler		
		100%	60%	20%
Tomatoes	\$0.60-0.85/lb.	\$1.05	\$0.94	\$0.83
Chrysanthemums	\$2.75-3.75/pot*	\$2.68	\$2.56	\$2.45

*6 1/2 inch.