COLORADO GREENHOUSE GROWERS ASSOCIATION, INC.

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PLANNING AHEAD FOR GREENHOUSE HEATING: 1980s and 1990s
PART I: WHAT ARE THE OPTIONS?

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Many greenhouse operators viewed the fuel crisis of the early 1970s as a hoax, and did not take any action to combat the rising fuel and electrical costs that are confronting them today. A few growers have incorporated the latest and best heat conserving programs, while others are either complacent, or have an outlook similar to the one that was expressed by Tony Mitchell (3), one of Great Britain's leading tomato growers. Mr. Mitchell was trying to analyze the conditions which caused tomato prices to fluctuate and made these timely thoughts which can be applied to any greenhouse crop:

> "There are many enterprises operating profitably — albeit at an uncomfortably low level — despite all the problems. Luck? Good management? More favourable circumstances? Some element of all, no doubt, but the greatest influence must surely be good management.
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> "Good management is the optimizing of the use of resources in a given situation in the short term and, in the longer term, seeking to improve the situation. The given situation at any time is the existing technology, the existing market and the existing location. The longer term is improving the technology, developing and increasing the market and, in the extreme, altering the location of the enterprise.
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> "Essentially, the technology must be applied both to inputs and output. Greater labour efficiency, greater fuel efficiency and greater marketing efficiency per unit of output are the key inputs. Increased yield and quality per unit of input are the key outputs. Per unit of input or output are the important criteria.
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> "*A classic case of losing sight of these criteria is energy saving by double glazing, thermal screens or even operating at lower temperatures.* There is no virtue in energy saving *per se*, only in reducing the proportion of sales revenue that has to be handed over to the fuel supplier. So far, there is little evidence that this has been achieved. Equally, saving labour costs at the expense of yield or quality has many times proved to be counterproductive.
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> "Increasing yield per unit of output will only increase profitability if this occurs by an individual optimizing his resources in a given situation."

Several Colorado growers feel that they can increase their output, which is a mark of good management, and not worry about the costs of installing energy saving equipment. These same managers must also be aware of the prices they must charge for their products in order to get an adequate return.

Coal — Coming Back

Several Colorado growers are doing something about their input costs. Some have turned to coal as a source of fuel. Don Young, a well-known greenhouse heating expert in the Rocky Mountain Region, has indicated that coal fired boilers are on the way back, but they are not going to be as cost-free as the natural gas systems presently used by greenhouse operators. He stated: "The new coal fired boiler systems are not completely automatic, and someone must be present to oversee their operation and push a few buttons". He noted stokers have not changed since the early 1940s and the by-product, fly ash, still has to be disposed. Don also suggested that anyone seeking information on coal fired boilers, must be aware of the unneeded frills that have been incorporated on some newer boiler systems. Young also recommended that retrofitting should include a system that can use natural gas or oil during peak night winter needs and, if multiple, coal fired boilers are considered, they should be staged similar to the methods used by some greenhouse operators today.

The English are definitely considering coal as the greenhouse fuel of the future. They are already making great strides in developing coal and ash handling equipment. One company is designing a highly efficient fluidized-bed boiler for horticulture use. They have also improved the conventional methods of burning coal with the development of: "self de-ashing underground stokers, automatic ignition

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chain grate stokers and the pneumatic conveying of coal and ash" (5). Perhaps it would be wise for some of the American coal boiler makers to see what the English have learned in their work.

One of the drawbacks of coal is the need to meet the United States Environmental Protection Agency (EPA) requirements. In Colorado, the State Air Polution Control Board evaluates the pros and cons of all large industrial boiler systems and issues permits for all industry-type coal burning equipment. At this time, permits are not too difficult to obtain, if the engineering data shows the particulate matter of the combustible byproducts and SO_2 to be less than 0.1 lb and 1.2 lbs. per therm (100,000 BTU) respectively (1). EPA has the means of controlling potential polluting industries.

Waste Heat

Electric power plant authorities around the world have been evaluating the use of their waste heat for greenhouses, fish production or soil heating for a number of years. The French seem to be the most active in such programs and, in the United States, the Northern States Power Company in Minnesota has been a leader.

The earliest American waste heat prototype greenhouses were developed by the Tennessee Valley Authority (TVA) at the Mussle Shoals and Brown's Ferry Power Plants in Alabama. In 1980, TVA, in cooperation with Rhea County Commissioners, Dayton, TN, publicized the availability of 100 acres of ground adjacent to the Watts Bar Nuclear Power Plant (6). In a conversation with TVA economist David Burch, it was learned that a rental fee has not been developed for use in their promotions. They are finding it difficult to determine their costs and requirements that should be in a contract.

The New York State Power Authority has recently developed its first "proto-contract" with a commercial greenhouse operator, for waste heat from the Poletti Power Station in Astoria, NY. Mr. Bart Chezar provided the following partial criteria that were used to develop the contract, based on one acre of greenhouse area:

Water: At the present commercial rate.

Electricity: Prevailing industrial rates.

Waste heat: $1.65 per therm for the first year, compounded at 10% per year for the next five years. Minimum $6,000. Backup or supplemental heat would be steam available from the company at $4,000 per year, also compounded at 10% per year for five years.

Maintenance: On lines to the greenhouse facility, $2500 per year.

Ancillary facilities: $17,000 per year.

The figures were computed on the BTUs obtained from 1000 barrels of oil per acre. Based on the minimum dollars only, the greenhouse operator would be paying 67.7¢ per sq.ft. for heat the first year, plus the cost of the electricity to run the circulating pumps.

The Colorado State Univ., Dept. of Horticulture, along with Dave Ashley of Ashley Associates, St. Paul, MN, have been working with the Basin Electric Company, Bismarck, SD, regarding the feasibility of locating greenhouses next to their Laramie River Power Station in Wheatland, WY. It appears they can supply "hot" water to the door of the greenhouse for approximately 44¢ per sq.ft. per year. Other feasibility studies in the U.S. place the costs near 37¢ per sq.ft.

The next factor to consider is the electrical energy required to move that hot water through the greenhouse. It could be calculated for winter only, but it would be more interesting to have a larger picture. The Edison Electric Power Station in Bender, MN, has a well documented greenhouse operation. The *total* utility bills have been approximately 50¢ per sq.ft. per year, e.g., hot water rent and electricity for a year. Even though it is only a 5000 sq.ft. facility, the electricity cost was about 13¢ to 15¢ per sq.ft. for the year. Electric generating plants are not the only sources of waste heat — but at present, they are the most adaptable.

Heat Pumps

The extraction of heat from water is the role of a heat pump. A number of pump companies are meeting the needs of some homeowners in the U.S., but few, if any, have proven that greenhouses can be economically heated unless the water is reasonably warm. The Detroit Edison Power Company has had much heat pump experience. Their Monroe, MI, power plant has been supplying 57° F (14° C) water, during the winter, to heat a 5000 sq.ft. greenhouse constructed in 1979. According to the director of market development, Jim Lagowski, they find the heat pump: "To be a capital intense piece of equipment and difficult to recapture the investment."

A commercial cucumber grower, Bob Munyon of Acampo, California, has gone through the 1981-82 heating season with a heat pump system. Bob says the system worked, but he made some changes for this season. The company supplying electricity could not tell him exactly what his power requirements were for the heat pumps, but he was relatively satisfied. Bob has three sources of water: his pond, which has a low temperature in the winter of approximately 45° F (7° C), a well with 68° F (20° C) water and a small runoff stream that is near 52° F (11° C). A temperature difference (ΔT) of 35° F (19° C) is used for engineering, because their expected low outside temperature is only 26 to 28° F (-3 to -2° C). In Colorado, we need at least a 50° ΔT (28° C). The water temperature in the pond may be low for greenhouse heating, but it is just right for the production of channel catfish, which, Bob says, is a going business.

The cooling water of electric generating plants ranges in temperature from 60 to 90° F (16 to 32° C) which is one of the reasons heat pumps have been so successful. Engineers indicate water temperatures below 50° F (10° C) are not practical. If such is the case, one should not be pushed into considering well water for very large installations. Home heating might prove alright, but not a commercial greenhouse.

Geothermal Heat Sources

Hot water from artesian and pumped wells has been used to heat some buildings for many years. A botanic garden greenhouse in Japan has warm water flowing in open concrete troughs for heating purposes. Gillham (2) made reference to a report written by M. Matheson describing the use of geothermal water to heat greenhouses in Iceland. Several installations use water sources of 212° F and it is transported through pipes 6 to 12 miles long. In 1970, there were approximately 28 acres of glass covered, geothermally heated greenhouses in Iceland. At the time, the cost of energy to the user was approximately 11¢ per therm (100,000 BTUs), which is $1.10 per million BTUs.

An old Nathrop, CO, greenhouse has been sold to a far-sighted greenhouse operator, Norman Denoyer. The water is hot enough to use for heating (160° F) with little pumping, and pure enough to use on most plants when it is cooled.

Another working facility is Gordon McCoard's greenhouse in Newcastle, Utah. Gordon spent almost $10 per sq.ft. constructing 80,000 sq.ft., and he is already realizing the payoff from his 204° F geothermal well. His total energy costs were 19.7¢ per sq.ft. for their first year. The house is double poly, with FRP side walls. Electricity cost more during the summer than in the winter because of the electric company summer pumping rates for irrigation farming. Gordon is going to change his peak electrical demand levels next summer.

Another Utah success story (7) is the operation of Utah Roses, Inc. One of their wells, 500 ft deep, provides 120° F water at 180 gal per minute for a 250,000 sq.ft. facility. The article stated that the well provides 50 to 75% of the heat for their Sandy, Utah, operation. Ralph Wright indicated that it appears pumping costs are being offset by the heat savings. (A $450,000 government grant through the Dept. of Energy was obtained for the first well).

A second greenhouse rose complex, recently developed by the Wrights, covers 130,000 sq.ft. A 400 ft well was drilled and 190° F water is to within 180 ft of the ground surface. They budgeted $1800 per month last year for all utilities and have the same budget again this year. A little "pencil farming" shows their total energy costs for the year to be 16.2¢ per sq.ft. of greenhouse area (approximately 21.5¢ per sq.ft. of bench area per year).

Ralph Wright volunteered some thoughts on geothermal heating: "There are definitely pluses and minuses, but geothermal has potential if the resources are in order, i.e., hot enough water, minimum pumping time and an economical way to dispose of the water". Utah requires geothermal well users to replenish the well water. In this case another well had to be drilled and the "spent" water pumped into the ground. Wrights hope to reduce their electrical cost more this year by using fewer cooling fans and more roof ventilation in the spring and fall.

A Marchwood, Southhampton, England, well has been drilled 5576 ft and produces a brine water of 158° F. The complex has a back-up coal boiler. When costs are amortized over a 20 year period, their energy is expected to be slightly less than coal and much cheaper than oil (4). The author further states that the drawbacks to geothermal are the capital outlay and government bureaucracy.

Solar Considerations

A greenhouse can be a relatively good solar collector, but a good solar collector makes a lousy plant factory. Analyze that statement for a moment and you will realize that adaptation of greenhouses for solar heating is out of the question economically. A separate solar collector system to heat soil is definitely worth considering, but the commercial greenhouse environment we diligently try to control, should not be degraded to the role of, or even considered, as a heat source until technology provides an economical, realistic method of doing so.

Literature Cited

1. Emission Control Regulators for Particulates, Smoke and Sulfur Oxides for the State of Colorado. 1982. Regulation No. 1. Colorado Air Quality Control Commission. Oct. 28, 1982.
2. Gillham, R.W. 1974. The feasibility of using waste heat in the Ontario agricultural industry: Technical and Economic Considerations. Progress report to the Hydroelectric Power Commission of Ontario. Toronto, Canada. June 1.
3. Mitchell, Tony. 1982. No virtue in energy savings alone. Supplement to the *Grower*. Jan. 21.
4. Smith, Ben. 1982. Heat pumps and geothermal energy may be too expensive. Supplement to the *Grower*. Jan. 21.
5. Strong case put for coal. 1982. The *Grower*, March 4.
6. Watts Bar Waste Heat Park - A proposed development. 1980. Rhea County Courthouse, Dayton, TN 37321.
7. Wright, C. Richard. 1981. Utah Roses Incorporated geothermal heat project. Roses Incorporated Bulletin. Sept.