Introduction to Workshop on the Use of Alternative Energy Sources in Horticulture
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Energy is like the air that we breathe, something that we have taken for granted for far too long. Almost every decade we have seen increased, almost insatiable, demands for more energy with little concern for supply or price. In the past decade, a grave threat to our national security as a result of our extensive dependence on unstable foreign oil supplies and escalating energy costs sobered up our energy thinking.

While supply shortages created crises in the 1970s, an oil glut, epic plunges in oil prices, and a blockade of the oil shipping lanes have threatened world peace and economic stability in the 1980s. The recent adventures of oil have been aptly described in Time magazine as a breathtaking and dangerous slide down a slippery slope.

A dangerous, slippery, rollercoaster ride might best describe the direction of both oil and the world’s energy situation. Kirshling (11) has noted that the general energy situation and international political climate will worsen in the future. The Organization for Economic Co-operation and Development has predicted an oil scarcity in the early 1990s, with rapidly hardening prices that would cause economic chaos in both industrial and developing countries (9).

Energy supply and price will be a continuing problem against which all the world will have to adjust by reducing its demand for nonrenewable fossil fuels and using alternative energy sources. Horticulturists have not been and will not be exempt from this continuing supply-demand-price energy problem. We have already experienced some worrisome episodes. Some of us may recall the government’s attempts to cut off natural gas used to heat greenhouses in Ohio. Or you may remember the high cost of tractor fuel.

Horticulturists have adjusted to some of these energy crises. In many areas, the efforts in energy conservation have been both admirable and outstanding. For example, some horticulturists revolutionized the way that they generate, use, and especially conserve heat and energy in the production of greenhouse crops (1, 3, 18). Unfortunately, conservation alone, no matter how efficient, will not solve the energy problem. Temporarily, conservation has allowed some horticultural industries to remain profitable, but energy prices still remain high. The total energy supply or reserve, the amount of coal, oil, and gas, has not increased.

The survival of horticulture and our current standard of living will depend on efficient energy use and management. A integral part of a successful energy management program will involve our ability to use alternative energy sources. While the oil bust of the 1980s has temporarily spoiled the economics of alternative energy sources, former Energy Secretary John Herrington has noted that the United States “is never going back to 1973; we’ve had a major change-over” (13). Conservation measures and use of alternative energy sources have enabled the industrial economies to grow without increasing use of energy at the same rate (13). For the time being, America is no longer at the mercy of the Oil Producing Exporting Countries (OPEC), due to its irreversible efforts to conserve energy and use alternative energy sources. In the wake of the Chernobyl nuclear meltdown and an increasing “greenhouse effect” due to the burning of fossil fuels, alternative energy sources may be needed sooner than most people think (7).

Alternative energy sources generally fall into two categories, reject or waste energy and biomass production. Reject energy is usually in the form of heat. In biomass production, waste products (12) or crops (6, 9, 16) are used directly in combustion to replace fossil fuels or used indirectly as biochemically transformed fuels such as alcohol. Despite changing economic conditions, the United States now only uses a fraction of its reject heat sources (4). There is enough reject energy in the United States at present to supply the energy needs of every greenhouse in the country (14). If greenhouse producers of horticultural crops in the Midwest and Northeast could reduce their energy costs, they would improve their ability to compete with growers located in Latin America and warm areas of the United States (18). The economic feasibility of greenhouse vegetable production with reject energy is being considered at Pennsylvania State Univ. under the direction of John White. Food processing plants are being fired with beet sugar and potato wastes (12). In Alabama, we have fueled tractors with energy generated from crop residues and animal wastes. It might be noted that wood, crop residues, and animal wastes are the main energy source for 80% of all the people in developing countries (12). More alternative energy sources must be used in horticulture, such as waste energy from power plants, refineries, distilleries, natural gas stations, waste incineration plants, and industrial mills (1, 4, 5). Agricultural, municipal and industrial wastes (6, 12, 18), along with geothermal (8, 10, 17), wind (17), and solar energy (2, 3, 8) are promising alternative sources with high potential in horticulture. One of the most interesting alternative energy sources is under investigation by Nobel prize winner Melvin Calvin. A combination of natural photosynthesis and genetic manipulation is to be used to produce a plant high in hydrocarbons for biomass conversion.

Technology to use alternative energy sources in economically productive systems must be developed before maximum benefits can be realized. It is the purpose of these papers, which grew out...
of a workshop, to discuss some of the developing technology on the use of alternative energy sources in horticulture. Horticulture must make a determined effort to solve its energy problems. There is a need for a clearly defined and enthusiastically supported policy of energy use in horticulture. Some time ago, I read an article on "Einstein's New Formula for Personal Energy" (7). It used the familiar formula, \( E = Mc^2 \). However, some of the symbols had been given new meanings. The "\( E\)" stood for energy, but the "\( M\)" stood for motivation and the "\( c\)" stood for commitment in this new formula. Horticulturists must become equally aware of the problem if they are to solve horticulture's energy needs. We must be motivated and make a commitment or eventually freeze in our glass palaces along with the tomatoes.

**Literature Cited**


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**Ethanol Production from Food Processing Wastes**

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Liquid fuels, the most versatile form of energy, primarily are produced from oil. They are subject to wide price fluctuations and critical shortages. Ethanol, which can be used as a liquid fuel or liquid fuel supplement, readily can be produced from starch and sugar feedstocks. Ethanol production from cellulosic sources or biomass can provide renewable, domestically produced fuel from the decentralized sources of U.S. farms and forests. Such production has other strategic implications for the United States, such as strengthening the farm economy, reducing vulnerability to oil boycotts, and reducing the amounts of dollars exported. More information is available on using ethanol in internal combustion engines than any other nonpetroleum-based liquid fuel. For these reasons, ethanol represents the best near-term choice for a liquid fuel from biomass.

Using conventional ethanol production technology requires about the same amount of energy to grow and convert starch and sugar crops into ethanol as the ethanol contains (15). Non-premium fuels, such as coal, or renewable fuels, such as wood, produce a net gain of energy from premium fuel production. Oil displacement can be even more significant if ethanol is used as an octane-boosting additive to gasoline rather than as a fuel. Ethanol prices are heavily subsidized and only marginally competitive with gasoline for direct fuel use. However, ethanol is cost-effective as an octane enhancer and, as a result, the U.S. market for ethanol is expanding (19). Ethanol is also widely used as a feedstock to produce other chemicals. Fermentation ethanol is competitive with ethanol from petroleum sources and, as a result, other chemicals are being produced from renewable resources (4).

Food processing plants produce substantial wastes composed predominantly of sugars and starches. These wastes can be used for conventional ethanol production in a separate system or integrated into the processing plant. This review a) assesses the food processing waste resources available, b) discusses methods of ethanol production from the wastes, c) determines feasibility of ethanol production, and d) determines the economics of producing ethanol from food processing wastes.

**Waste resources**

Fruits and vegetables account for 89% of all processed food. The distribution of vegetable and fruit wastes in the United States is shown in Tables 1 and 2. Crop culls, another food waste, will not be discussed because of a lack of published data and a decline in the amount because of mechanical harvesting. Previously, hand harvesters could easily and efficiently sort cull material in the field. In general, processed fruits and vegetables are either canned or frozen (1). Most processing wastes are generated by either peeling or slicing. Up to 89% of the waste generated is from peeling in some cases (20). These wastes are extremely hard to treat.

Liquid wastes from washing or conveyance carry a large amount of fermentable carbohydrates (85% to 95% of total solids), but in dilute form (1). Liquid wastes are usually treated in a biological process such as activated sludge, oxidation ponds, lagoons, or land application. Sugar concentration by reverse osmosis (RO) has been studied to reduce waste treatment costs and generate revenue through ethanol production (3). Wastewaters containing <0.2% sugar would be too costly to process using this method. We concluded that the total national potential quantity of fuel-grade ethanol from RO would be ≈12% of the ethanol derivable from all usable crop residues. Solid wastes such as vine, leaves, and damaged or undersized crops have the lowest moisture content and thus represent the most usable residue form. Other solid wastes include peels, trimmings, fragments, skins, pits, cores, spillage, pulps, and seeds (1). These wastes usually have a higher moisture content since they absorb liquid during water conveyance. The exact composition of these wastes is unknown, but should be similar to the raw materials. The typical compositions of raw vegetables and fruits are given in Tables 3 and 4.

**Methods of ethanol production**

An understanding of ethanol production methods aids in establishing the advantages and disadvantages of using various feedstocks. A flow diagram of the process steps involved in ethanol