ENERGY RESOURCES FOR AGRICULTURE

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Summary

Before the nineteenth century, food production was energized by the instantaneous flow of solar energy. The only other energy input was human and animal effort. Primitive farmers were able to feed their small families but few others. By the middle ages, agricultural producers were able to feed themselves and a growing urban population. Since the advent of the industrial age, energy input to food production systems has increased to enable a modern farmer in a developed country to produce enough food for as many as 90 people.

World population has increased because of reliable food supplies produced largely by the widespread use of additional energy in food production systems. The added energy, usually termed cultural or support energy, and referred to as an energy subsidy, has been almost entirely obtained, directly or indirectly, from two fossil fuels, petroleum oil and natural gas. Except for overpopulation problems, the coming fossil fuel energy scarcity is a serious threat for most of the world.

This discussion is concerned mainly with the supply of energy for agricultural production, that is, gasoline and diesel fuel for mobile equipment and on-farm processing. Liquid fossil fuels are used in engines for mobile equipment because of their characteristic high energy content per unit mass, 43 to 45 MJ/kg (megajoules per kilogram), their ability to vaporize at least partially at low temperatures, their ignition and burning properties when mixed with air, and their relative ease and safety in handling, storing and transporting

The three energy options closest to being practical substitutes for gasoline and diesel fuels in the near future are methanol and ethanol, compressed natural gas (CNG) or liquid natural gas (LNG). Methanol and ethanol can be produced from renewable biomass materials and can be low polluting fuels for transportation use. But there are significant energy costs in the production of methanol and ethanol (biodiesel).

Two lessons that should have been learned in the energy field in past years are to expect unexpected events and to be very careful of trend analyses based on extrapolating past trends. The present concerns for environmental pollution and global warming may dictate future energy use. Developing appropriate practical renewable energy sources and technologies is another method of conserving fossil fuels for use as liquid fuels. Since the first oil supply shock of 1973, energy conservation, rather than renewable energy or alternate energy, has emerged as the main new energy resource.

1. General discussion of energy and agriculture

Prior to the early nineteenth century, food production was energized by the instantaneous flow of solar energy. The only other energy input was human and animal effort and the almost incidental input of plant and animal residues. Primitive or subsistence farmers were able to feed their small families but few or no others. By the middle ages, through advances in farming techniques, agricultural producers were able to feed themselves and an ever increasing urban population. Society remained predominately rural, with 80 percent or more of the economically active population engaged in agriculture. It is estimated that by 2020 the majority of the people in the developing countries will be living in urban or suburban areas.

If human societies had remained as hunter/gatherers it is estimated that the total world population would have increased to only about 10 million people because of limited food supplies. But with evolving agricultural technology, total world population slowly increased to about 1.5 billion by 1900. People freed from the daily pursuit of food and water were free to develop the arts, science and other human cultural activities. Since the advent of the industrial age, energy input to food production systems has increased to enable a modern farmer in a developed country to produce the equivalent of enough food for as many as 90 people. In most highly developed countries, less than five percent of the total population is engaged in primary agriculture.

World population has increased to about six billion because of reliable food supplies produced largely by the widespread use of additional energy in food production systems. The added energy, usually termed cultural or support energy, and referred to as an energy subsidy, has been almost entirely obtained, directly or indirectly, from two fossil fuels, petroleum oil and natural gas. There is now concern that with continued depletion of fossil fuel reserves agriculture will not be able to sustain or increase food production at the level necessary to support growing world populations. There is also concern that emissions from the burning of fossil fuels must be controlled to protect the environment.

The coming energy dilemma of relatively inexpensive yet dwindling petroleum fuels is a very serious economic and environmental threat facing most of the world and its high or improving standard of living. Except for overpopulation problems, the coming fossil fuel energy scarcity is a serious threat for most of the world. There are, however, reasons to be optimistic about the outlook for traditional fossil fuel energy supplies for sustainable agriculture for the foreseeable future. Also, practical alternate fuels will become increasingly available and competitive with remaining fossil fuels and will eventually replace them.

The energy supply problem has an economic, a political, and an environmental dimension, all of which are very complex. Conservation of energy is an excellent approach to the energy problem and will require new ways of thinking about technology. Conservation methods need not be overly sophisticated to be effective in reducing emissions and extending oil, coal and gas reserves.

Throughout most of the twentieth century, increases in supplies of petroleum fuels have comfortably kept pace with demand. There have been periodic shortages and times of rising prices, but proven reserves for the world currently stand at an all time high of 1,000 billion barrels (one barrel = 42 US gallons = 0.159 cubic meters). Proven reserves of petroleum oil are defined as the amount of petroleum oil that is recoverable under current economic and technical operating conditions. The amount of the ultimately recoverable petroleum oil may be six times the proven reserves. Of the remaining proven petroleum reserves, approximately 75 percent are in countries of the Middle East.

Towards the end of the 20th century, the world's energy supply was dominated by fossil fuel resources in the form of oil. By about 1973 energy from oil alone accounted for about 50 percent of energy use. Other sources of energy were natural gas, coal, and electricity generated by water power or nuclear reactors. Efforts in conservation and the more efficient use of energy have lead to less growth in energy demand than had been predicted in the middle 1970s. Shifts in the sources of energy occurred, so that by the late 1980s only about 40 percent of the total energy used was supplied by oil. More energy is now supplied by natural gas, coal and electricity.

The change in energy supply sources was caused by perceived smaller reserves of oil as compared to natural gas and coal. It should be noted that new discoveries and rising oil prices tend to increase the proven reserves. The estimates of proven reserves are of concern and indicate that alternate sources of energy should be seriously considered. Predicting exactly when the world's oil, gas and coal resources will be exhausted is not really possible. Fortunately for the world, there are several energy options to conventional fossil fuels. Continued energy conservation, the adoption of more efficient technology and the development of solar energy processes and less easily accessed fossil fuel reserves (e.g., tar sands) are just a few of the options.

Agricultural production makes little demand on the total energy supply system when compared to transportation and industrial uses of energy. In most countries there are no regulations to ensure the supply of energy, in the form of fuel and fertilizer, for the production of food in times of crises. On-farm energy use includes direct energy and indirect energy inputs.

These energy inputs are variously applied to the production of crops and animals or animal products. The direct energy inputs to agriculture are in the form of gasoline, diesel fuel, electricity, and space heating fuels, including natural gas where available and are used in the production of crops and animals. Direct fuel use in farm production can be as high as 50 percent of total farm energy use. There is considerable variation on individual farms in the percentage of total farm energy use represented by direct fuel use.

The indirect energy inputs consist of fertilizers, seed, pesticides and the energy embodied in the manufacture and supply of machinery. In addition to the concerns about the supply of the energy embodied in these inputs, one might also be concerned about the supply of the basic resources needed to manufacture the inputs, that is the iron and steel for machinery, the raw materials for the pesticides, and the nitrogen, phosphorous and potassium for fertilizers. We live in a finite system where either energy supply limits or raw material supply limits will define some sustainable scope to human activities.

While overall energy supplies are important, the discussion in this section is concerned mainly with the supply of energy for agricultural production, that is, gasoline and diesel fuel or fuel for mobile equipment and on-farm processing. Liquid fossil fuels are used in engines for mobile equipment because of their characteristic high energy content per unit mass, 43 to 45 MJ/kg (megajoules per kilogram), their ability to vaporize at least partially at low temperatures, their ignition and burning properties when mixed with air, and their relative ease and safety in handling, storing and transporting. Fuels for industrial use can be solid, liquid, or gaseous but for mobile equipment and transportation use liquid fuels are better suited.

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