111. ENVIRONMENTAL EFFECTS

Perceptions about the environmental benefits and costs of gasohol have focused on the potential air quality effects of emissions from gasohol-powered automobiles. Each stage of the gasohol "fuel cycle" has significant environmental effects, however, and the most important effects are likely to be the result of growing and harvesting the ethanol "feedstocks" - starch and sugar crops, crop residues, grasses and wood.

OBTAINING THE FEEDSTOCK

Starch and sugar crops would be the most likely near-term candidates for the ethanol feedstocks of a large-scale gasohol program; proven conversion technologies exist for these crops, and large acreages suitable for conversion to intensive agriculture are currently available. At the present time, pressure to promote gasohol is stressing the use of surplus and distressed crops as well as food wastes, but supplies of these feedstocks are limited. A commitment to produce quantities of gasohol greater than these sources can provide (i.e., more than a few hundred million gallons of ethanol per year) must involve additional crop production through more intensive cultivation of present cropland and the development of "potential" cropland currently in forest, range or pasture. A commitment to produce enough gasohol to supply most U.S. automotive requirements could involve putting approximately 30-70 million additional acres into intensive crop production. Assuming the acreage was actually available, this new crop production would accelerate erosion and sedimentation, increase pesticide and fertilizer use, replace unmanaged with managed ecosystems, and aggravate other environmental damages associated with American agriculture.

Soil erosion and its subsequent impact on land and water quality will be a significant impact of an expansion of intensive agricultural production. Current agricultural production is the primary cause of soil erosion in the U.S.: between 2 and 3 billion tons of soil from American farms enter the nationts surface waters each year. (28) The soil particles cause turbidity, fill reservoirs and lakes, obstruct irrigation canals, and damage or destroy aquatic habitats. In addition, they transport other water pollutants including nitrogen, phosphorus, pesticides, and bacteria. (28) Although the extent of the damage to aquatic ecosystems is unknown, yearly material damage from sedimentation has been esttiated at over S1 billion. Aside from damages associated with these water impacts, allowing a sustained soil loss of more than about 5 tons/acre year eventually will rob the land of its topsoil. Average erosion rates on intensively managed croplands currently exceed these levels by a considerable margin. For example, sheet and rill erosion alone on intensively managed croplands averages 6.3 tons/acre year nationally and 7.3 tons/acre year in the Corn Belt. (30) These high rates of erosion are allowed to persist because in all but the most severe cases the loss of valuable topsoil is slow. A net loss of 10 tons/acre year leads to a loss of only an inch of topsoil in 15 years. Depending on the depth of the topsoil and the depth and quality of the subsoil, the loss in productive potential over this length of time may be significant or negligible. Even a significant loss may go unnoticed, because it is masked in the short term by productivity improvements resulting from improvements in other farming practices or more intensive use of agricultural chemicals. Eventually, however, continuing losses in productive potential could cause a leveling off and even a decline in U.S. farmland productivity.

Erosion from current production appears to be a reasonable model on which to base evaluations of future erosion potential from ethanol crop production. An examination of Soil Conservation Service land capability data indicates that the lands most likely to be shifted to intensive ethanol feedstock production are somewhat more erosive than land that is currently being cultivated, but not excessively so. On a national basis, 48% of the land in intensive crops is erosive compared to 53-60% of the land that is most likely to be shifted to intensive production. (30) Although precise data are not available, the land currently set aside probably would be both the first to be used and the most erosive of the land base for biomass energy crops.

The extent of any erosion problem will depend on the type of crops grown. In general, annual crops are more erosive than perennials, and row crops more than close-grown crops. Thus, corn (an annual row crop), the most widely discussed gasohol crop, would be among the most erosive; forage grasses (perennial close-grown crops) may be among the least.

A large expansion in intensively managed cropland will have important impacts in addition to erosion damage. For example, pesticide use -- currently at about one billion pounds per year for the U.S. (29) -- will expand somewhat proportionately to the expansion in acreage. Although the long-term effects of pesticides are not well understood, some pesticides (e.g., Aldrin, Dieldrin, Mirex) have been banned from use because of their potential to cause cancer or other damage -- and it is possible that other widely-used pesticides will be discovered to be dangerous as more knowledge accumulates. Public interest in pesticide dangers to human health --

whether proven or merely perceived -- appears to be sharply on the rise. OTA considers it a strong possibility that public reaction to health damages reported to be linked to pesticide use may increase dramatically in the future. This may constrain both the continuing rise in pesticide usage and the expansion of crop production for energy feedstocks.

Another important issue concerns the heavy use of fertilizers on new cropland. Fertilizer application rates on this land probably will be high because the payoff in increased yield is well established. Runoff and leaching of nutrients to surface and groundwaters will cause premature aging of streams and other damage to aquatic ecosystems. In addition, natural gas must be used to produce nitrogen fertilizers for the new crops (or to replace the nitrogen embodied in the residues removed). At current application rates, 50 million acres of corn production would require over 100 billion cubic feet of gas per year, or over 1/2 of 1% of total U.S. natural gas production.

The increase in cropland also would involve a transformation of unmanaged or lightly managed ecosystems -- such as forests -- into intensively managed systems. For example, approximately one quarter of the land identified by USDA as having a high or medium potential to become cropland is forest, (31) and the Forest Service considers this land -- especially in the Southeast -- as a prime target for conversion. A full-scale national gasohol program could increase the pressure to clear as many as 10 to 30 million acres of unmanaged or lightly managed forest.

All of the impacts associated with increased crop production are functions not only of the type of crops grown but also of land capability, production practices, improvements made to the land, and other factors- There is enough freedom of choice in the system to significantly reduce the environmental impacts of a major gasohol program. Aside from choosing the land to be cultivated as well as the crop and tilling procedure, farmers may use a variety of environmental protection measures such as integrated pest management procedures, soil analysis to minimize fertilizer applications, and the development of disease-resistant crops to reduce impacts. The Environmental Protection Agency (through its 208 areawide planning process to control nonpoint sources of pollution) and the Department of Agriculture (through the Soil Conservation Service programs) have made only limited progress, however, in shifting farming practices toward more environmentally benign and soil conserving methods. (32, 33) Also, there is considerable controversy surrounding the net environmental effects and the potential impacts on crop yields of some of the measures advocated as environmentally beneficial. For example, conservation tillage, advocated as an extremely effective erosion control, requires increased applications of herbicides and insecticides (34) (the latter to combat insects that are sheltered by crop residues left on the surface as a mulch). Loss of these pesticides to surface waters will be slowed by lessening erosion, but increased contamination of groundwater may still result. Similar ambiguities, especially about the possibility of lowered net yields, surround measures such as pest “scouting” (monitoring), organic farming procedures, and other practices.

In light of farmer resistance to controls, the apparent lack of high priority given to most agricultural environmental problems by the EPA, and the possibility that certain environmental measures may replace one adverse environmental impact with another (for example, conservation tillage replacing erosion with increased herbicide use), OTA concludes that the environmental effects of converting tens of millions of acres to intensive production may be at least as great as the effects observed on similar acreage today.

Although food crops currently may represent the most economic ethanol feedstock, the potential for substantial increases in corn (and other sugar/starch crop) prices and for improvements in conversion processes for alternative feedstocks points to the eventual primacy of these alternative feedstocks in ethanol production. The use of crop residues, forage grasses, and other alternative feedstocks will have environmental consequences that are substantially different from those caused by growing and harvesting sugar/starch crops.

Crop residues may be used either as an ethanol feedstock or as a distillery boiler fuel. Although leaving crop residues on the surface is an important tool for erosion control, substantial quantities can be removed from flatter, less erosive soils in some parts of the Corn Belt and elsewhere without causing erosion to exceed 5 tons/acre year. (35) Qso, many farmers plow these residues under in the fall to prevent them from harboring crop pests or to allow an earlier spring planting, thus losing their protection anyway. Thus, the use of residues will cause additional erosion only if they otherwise would have been left on the surface, and only if they are removed from erosion-prone lands or in excessive quantities. Unfortunately, conflicts between short-term profits and long-term land protection could easily lead to improper use of residues unless effective institutional controls or incentives for environmental protection can be developed. Also, there is some concern (although little substantive evidence) about possible harmful effects of reductions in soil organic levels caused by residue removal.

The intensive cultivation of forage grasses would cause pollution effects from fertilizers and pesticides, but could be expected to produce far lower levels of erosion than food crops (as noted above).

The major factor controlling the impact of these alternative feedstocks will probably be the efficiency with which they can be converted to ethanol. A breakthrough in conversion efficiency could nearly double alcohol production per ton of feedstock and halve the acreage -- and impacts -- necessary to sustain the desired gasohol use.

ETHANOL PRODUCTION

Significant environmental effects of ethanol production are associated with its substantial energy requirements and the disposal of distillation wastes.

New energy efficient ethanol plants probably will require about 50,000-70,000 BTU per gallon of ethanol produced to power the distilling, drying and other operations. Individual distilleries of 50 million gallons/year capacity will use as much fuel as 50-70 MW powerplants; a 10 billion gallon per year ethanol industry will use about the same amount of fuel as needed to supply 10,000-14,000 MW of electric power capacity.

New Source Performance Standards have not been formulated for industrial combustion facilities, and the degree of control and subsequent emissions are not predictable. The most likely fuels for these plants will be coal or biomass (crop residues), however, and thus the most likely source of problems will be their particulate emissions. Coal and biomass combustion sources of the size required for distilleries -- especially distilleries designed to serve small local markets -- must be carefully designed and operated to avoid high emission levels of unburned particulate hydrocarbons (including polycyclic organic matter). (36) Fortunately, most distilleries will be located in rural areas, and this will reduce total population exposure to any harmful pollutants.

The effluent from the initial distillation step -- called “stillage” -- is very high in biological and chemical oxygen demand and must be kept from entering surface waters without treatment. The stillage from corn and other grains is a valuable feed byproduct and it will be recovered, thus avoiding this potential pollution problem. The stillage from some other ethanol crops is less valuable, however, and may have to be strictly regulated to avoid damage to waterways. Control techniques are available for the required treatment.

If fermentation and distillation technologies are available in a wide range of sizes, small scale on-farm alcohol production may play a role in a national gasohol program. The scale of such operations may simplify water effluent control by allowing land disposal of wastes. On the other hand, environmental control may in some cases be more expensive because of the loss of scale advantages. Also, the current technology for the final distillation step, to produce anhydrous alcohol, uses reagents such as cyclohexane and/or ether that could pose severe occupational danger at inadequately operated or maintained distilleries. Although alternative (and safer) dehydrating technologies may be developed, in the meantime special care will have to be taken to ensure proper design, operation and maintenance of these smaller plants.

The decentralization of energy processing and conversion facilities as a rule has been viewed favorably by consumer and environmental interests. Unfortunately, a Proliferation of many small ethanol plants may not provide a favorable setting for careful monitoring of environmental conditions and enforcement of environmental protection requirements. Regulatory authorities may expect to have problems with these facilities similar to those they run into with other small pollution sources. For example, the attempts of the owners of late model automobiles to circumvent pollution control systems conceivably may provide an analog to the kinds of problems that might be expected from small distilleries if their controls prove expensive and/or inconvenient to operate. Congress should carefully weigh the potential costs and benefits of centralized vs. decentralized ("on-farm") plants before providing incentives that might favor one over the other.

GASOHOL USE

The effects of gasohol use on automotive emissions are dependent on whether the engine is tuned to run fuel rich or lean and whether or not it has a carburetor with a feedback control. Although some gasohol advocates have claimed that the emissions effects are strongly positive, in fact it is difficult to assign either a beneficial or detrimental net pollution effect to gasohol use.

Gasohol use will have the following effects on most cars in today's automobile fleet (i.e., no carburetor modifications are made and fuel "leaning" takes place): (9)

- increased evaporative emissions (although the new emissions are not particularly reactive and should not contribute significantly to photochemical smog)
- decreased emissions of carbon monoxide
- increased emissions of aldehydes (which are reactive and conceivably may aggravate smog problems)
- increased NOX emissions with decreased emissions of exhaust hydrocarbons, or decreased NOX with increased HC (depending on the state of engine tune).

The emissions effects on automobiles which are manually or automatically adjusted to maintain constant air/fuel ratios (i.e., no "leaning" effect) will be considerably less.

This mixture of observed emissions reductions and increases, and the lack of extensive and controlled emissions testing, does not justify making a strong value judgement about the environmental effect of gasohol used in the general automobile population (although the majority of analysts have concluded that the net effect is unlikely to be significant). It may be possible to engineer an unambiguously beneficial effect, however, by channeling gasohol to certain urban areas with specific pollution problems (for instance, high carbon monoxide concentrations but no smog problems) or to vehicle fleets with engine characteristics that could maximize potential benefits from gasohol. The federal government could stimulate this type of use by initiating federal fleet use as an example, and by providing economic or regulatory incentives to fleet operators or to areas that would benefit from gasohol use.

GLOBAL EFFECTS OF THE GASOHOL FUEL CYCLE

The emission of carbon dioxide (CO_2) has become a major issue in the debate over synthetic fuels production.

Net CO_2 emissions from the gasohol fuel cycle are dependent on the extent and nature of land conversion needed to grow the feedstock, the fuel used to fire the distilleries, overall energy efficiency of the fuel cycle, and the type of fuel displaced (gasoline from natural crude or gasoline from coal-derived synfuel). If a minimum of forested land is permanently cleared for growing ethanol crops, if the major distillery boiler fuel is crop residues or some other renewable fuel, and if the ethanol is efficiently used (as an octane booster), then universal use of gasohol will reduce current CO_2 emissions from automobile travel by about 10%*.

It should be stressed, however, that even maximum use of alcohol fuels in the U.S. can have only a small effect on total worldwide CO_2 emissions. A combination of major changes in the current energy system and a significant slowdown of deforestation, effected on a worldwide scale, would probably be needed to put a brake on increasing atmospheric CO_2 levels.

* One uncertainty in this conclusion is the extent to which organic loss on cultivated land is an important CO_2 source”