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ETHANOL

IS IT THE RIGHT DECISION?

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The world's growing energy needs have been the subject of debate over the past several years. Our nation's consumption of energy and our interrelated demands for energy have been a topic of debate for decades. Security of United States energy sources came into question with the '70s oil price shocks. This event was soon followed by a heightened awareness of the environment. Society was concerned about automobile emissions and air pollution. These two national issues provided an opportunity for proponents of alternative fuels to obtain federal excise tax exemptions and investment tax credits. Is the decision to spend these dollars wise? Who benefits from these policies and who doesn't? Is ethanol a good choice as an alternative fuel?

This paper looks at the economic and energy budgets of grain-based alcohol, or ethanol, through three different theoretical or conceptual decision-making perspectives. The first perspective is the traditional or classical decision-making process. The second perspective discusses value-focused thinking, and the third focuses on the holonomic best decision-making process.

BACKGROUND

Ethanol, or ethyl alcohol, is the substance used in "gasohol," a blend of 90 percent unleaded gasoline and 10 percent ethanol. Ethanol is produced

from grain and biomass sources. In the United States this has typically meant corn. The public has been led to believe that ethanol blends reduce the demand for crude oil, improve fuel economy, reduce pollutant emissions, and improve vehicle performance.

"Alcohols have been used directly as motor vehicle fuels or in gasoline blends since the earliest days of the automobile" (Austin and Rubenstein, 1981, p. 2682). Following World War II, industrial alcohols replaced grain-based alcohols due to price, while abundant supplies of low-priced gasoline limited the use of alcohols.

In 1973, the year of the Arab oil embargo, Nebraska reduced its gasoline tax by three cents per gallon for fuels that contained a minimum of 10 percent agricultural ethanol.

> In 1977, Senators Carl Curtis (R-Nebraska) and Robert Dole (R-Kansas) co-sponsored an amendment to a farm bill that directed the U.S. Department of Agriculture (USDA) to develop four pilot alcohol production plants. USDA's position on the amendment was that alcohol fuel production from crops would not be economically viable. The U.S. Department of Energy (DOE) took the position that it would take more energy to produce ethanol than it would yield. The amendment was adopted nonetheless. (Austin and Rubenstein, 1981, p. 2683).

The Clean Air Act Amendments of 1977 prohibited the addition of ethanol to fuels on 1975 or subsequent model vehicles. EPA reported that in 10 percent concentration in unleaded fuel, ethanol has a statistically significant adverse effect on emissions. The EPA is authorized to waive this prohibition if it is determined that the additive will not cause or contribute to the failure of any vehicle to meet the applicable emissions standards. Gas Plus, Inc. and the Illinois Department of Agriculture requested a joint waiver in 1978. In lieu of denying this request, EPA issued a statement that it would not act on the request. Subsequently the waiver went into effect. EPA's reasoning was that

current and expected gasohol use was small and would not pose a significant environmental risk (Austin and Rubenstein, 1981).

In 1978, the National Energy Act was approved by Congress, It included a four cent per gallon federal excise tax exemption on alcohol-gasoline blends which contained at least 10 percent alcohol manufactured from agricultural products or wastes. This Act effectively reduced the cost of ethanol by 40 cents per gallon since it was blended into gasoline at a ratio of 1:9. Since then many states have provided incentives for ethanol production. This federal exemption is currently 60 cents per gallon (United States Department of Agriculture, 1994). All tax reductions are all made up through other broad-based taxes and taxes charged on conventional fuels (Austin and Rubenstein, 1981).

In a report from Resources for the Future, Walls, Krupnick and Toman (1989) concluded that at the crude oil prices of the time, ethanol fuel could not compete with gasoline without the current subsidy of 60 cents per gallon. They stated that the subsidy would generate allocative inefficiency in the ethanol market unless external benefits from its use were realized.

The 1990 Clean Air Act Amendments mandated high-octane motor fuel contents--basically blending oxygenates such as methyl tertiary butyl ether (MTBE) or ethanol into gasoline and requiring the reformulation of gasoline to eliminate heavy metals and other toxins.

In the summer of 1994, Vice President Al Gore cast the tie-breaking vote in the Senate to uphold the EPA mandate requiring that "renewable fuels" provide 30 percent of the oxygenate content of reformulated gasoline. This is considered a boon to corn growers and ethanol producers.

ECONOMIC EFFECT OF ETHANOL USE

Ethanol costs more to produce than gasoline. Hoffman (1994) states, "...ethanol still faces two major hurdles to its growth. Fuel-grade material presently costs $1.20 per gallon, making it far more expensive than gasoline, and limits on the size of the corn supply threaten to restrict the amount of alcohol that can be produced from grain" (p. 3). It is clear that ethanol cannot survive without government subsidies because the wholesale price of gasoline is around $.70 per gallon. Due to various federal and state subsidies and incentives, along with attendant federal agricultural programs, the true costs of ethanol are hidden and precise and detailed analysis of costs of ethanol programs is beyond the scope of this paper. A review of the literature reveals an extraordinary controversy over whether ethanol programs will cost federal taxpayers or reduce their burden. Predictions range from a net loss to the taxpayer of $7.2 billion to a net gain of $2 billion through 1995.

Irshad Ahmed, a senior research engineer at the Institute for Local Self-Reliance, Washington, D.C. reports that the U.S. currently produces one billion gallons of ethanol from corn. Based on the available corn supply, this can grow to three billion gallons before ethanol production will start effecting the available food supply and the price will rise (Hoffman, 1994). Kane and LeBlanc (1989) state that gains to crop farmers specializing in corn, sorghum, and wheat would be offset by losses from livestock producers and crop farmers specializing in soybeans or those who combine cotton and soybeans. It is interesting to note that Kane and LeBlanc (1989) report, "The 1984 ethanol subsidy of approximately $15 per million Btu's is more than 50 times greater than that of petroleum, natural gas, or coal."

Non-Market Benefits of Ethanol Use

The perceived non-market benefits of ethanol use relate to energy security and environmental improvements.

Environmental Improvements

Walls, Krupnick, and Toman (1989) state, "The use of ethanol fuel, or any alcohol blended with gasoline, typically lowers vehicular exhaust emissions of carbon monoxide (CO) and hydrocarbons (HC) but increases emissions of nitrogen oxides (NO_X) and evaporative HC emissions" (p. 8). In 1981, Austin and Rubenstein published an exhaustive analysis of gasohol and made the following remarks pertaining to the environmental impact of ethanol use.

> Because the effect of gasohol on automobiles is highly dependent on engine design and calibration, there is a wide variety of data on how gasohol alters vehicle performance. Older, richly calibrated cars can exhibit improved fuel economy and lower exhaust emissions due to the mixture enleanment caused by the blending of ethanol into gasoline. However, late model automobiles experience reduced fuel economy and mixed exhaust emissions impacts when gasohol is used. The principal environmental impact of gasohol is the substantially increased evaporative emissions which are experienced by most vehicles (p. 2681).

Reddy (1986) states in the conclusion of the paper, "...if alcohols are directly added to gasoline without volatility adjustment, evaporative emissions will increase significantly." In Yaccarino's 1989 SAE paper, the following conclusion was found:

> The reduction of CO emissions with open-loop (non-feedback) emission controls is well understood using simple chemical models of combustion. New (post 1980) vehicles, which utilize closed-loop (feedback) control of the fuel mixture, may not experience this reduction in CO emissions with oxygenated fuel. The reduction may not occur because the fuel mixture is adjusted by sensing the oxygen in the exhaust and controlling the fuel flow accordingly. Most newer models also employ adaptive learning which adjusts the initial fuel settings based on previous running of the engine. These two effects should, in theory, eliminate the

> leaning effect of oxygenated fuels when the mixture is held to stoichiometric by the closed loop system.

Gething, Welstand and Horn (1989) validate the above positions when they state that ethanol blends used in older cars (pre-1980) clearly show reduced CO emissions. Newer cars do not respond with the same CO emission reductions. They remind us that newer cars with little or no response to oxygenated fuels are constantly replacing older vehicles with large CO responses.

In 1993, the EPA claimed oxygenates use sharply cut CO levels, yet a decline in CO emissions was expected because newer vehicles emit CO at a much lower level than the older vehicles they replaced (Walls, Krupnick, and Toman, 1989). The following statement was reported in the *Oil and Gas Journal Newsletter* in April of 1993:

> Results of test programs in Colorado, New Mexico and Brazil, disclosed at the American Chemical Society annual meeting in Denver last week, show no statistically significant effect on oxygenates use on air quality. Larry Anderson, a chemistry professor at the University of Colorado at Denver, said carbon monoxide levels have been dropping the past 10 years, which may stem from increased use of unleaded gasoline and vehicle fleet turnover. ...Daniel Grosjean, with DGA Inc., Ventura, California, studied Brazil's fuel ethanol program and found incomplete combustion of ethanol results in emissions of acetaldehyde, related to formaldehyde, which EPA lists as a carcinogen. Formaldehyde emissions also have been linked to methanol fuels. Reuters quoted an EPA official as saying the reduced CO level was worth the added moderate emissions of formaldehyde. (p. 4)

Austin and Weaver (1990) report in a Sierra Research report that when hydrocarbon increases caused by ethanol are added to the maximum possible CO reduction, the projected net effect is a six percent increase in ozone-forming potential of vehicle emissions. The hydrocarbon increases are associated with

urban haze (smog) and increased respiratory disease in children, causing adverse air quality impacts. In essence, ethanol blends end up costing more and make the air dirtier.

A 1994 Chicago Sun-Times article written by Michael Briggs quotes Ron Burke, Director of Environmental Health for the American Lung Association of Metropolitan Chicago, by stating, "The best science today indicates that ethanol blends will actually make air quality slightly worse" (p. 20). This same article discloses that Browner of the EPA states "...blending of renewable fuels into gasoline won't make the air over Chicago any cleaner than it would become with reformulated fuel made entirely of petroleum products" (Briggs, 1994, p. 20)

ENERGY BUDGET OF ETHANOL

Austin and Rubenstein (1981) compiled an extensive report on gasohol. Included within the paper is a calculation of the net energy required for ethanol production, starting with energy requirements for farming operations and continuing through the process of converting corn to ethanol. They concluded that the net nonrenewable energy consumed in the production of 1 BTU of ethanol is 2.26 BTUs of energy, or more than twice as much energy to produce ethanol as was available from ethanol itself.

Since then technology improved. Pimental (1991) conducted an assessment of energy required to produce ethanol. The following table lists Pimental's energy inputs per gallon of ethanol.

ENERGY INPUTS PER GALLON OF ETHANOL

INPUTS	POUNDS	BTU
Corn	22.4	56,720
Transport	22.4	610
Stain. Steel	.05	1,348
Steel	.1	2,106
Cement	.27	909
Plant, Other		2,800
Water	1,279	1,364
Electricity	0.5 kWh	5,160
Fuel		60,000
TOTAL		131,017

Pimental states that the outputs per gallon of ethanol were placed at 76,000 BTU/gallon plus 11,000 to 32,000 BTU/gallon for the dry distiller's grain, yielding a range of total energy output of 87,000 to 108,000 BTU/gallon.

> The foregoing analysis, for which all major factors operating in ethanol production were assessed, confirms that ethanol production does not contribute to national energy security, is not a renewable energy source, is an uneconomical fuel, and its overall production system causes serious environmental degradation. This analysis generally substantiates the findings of ERAB (1980, 1981), GAO (1980), OTA (1980), USDA (1986), Dovring (1988), Pimentel et al. (1989), Walls et al. (1989) and Sparks Commodities (1990). Further it agrees with the latest GAO (1990) report that indicates there are numerous uncertainties concerning any supposed budgetary or other benefits of ethanol production for the nation. (Pimental, 1991).

PR Newswire (1994) reported that the U.S. Agriculture Department estimated energy inputs needed to produce ethanol from corn. Their estimate was a positive net energy balance of 108 percent--for every 100 BTUs of energy used to produce ethanol, 108 BTUs of ethanol are produced. After reviewing the report, entitled United States Department of Agriculture, Comments Concerning The Environmental Protection Agency's Regulation of Fuels and Fuel Additives: Renewable Oxygenate Requirement for Reformulated Gasoline Proposed Rule (1994), the author found no real arguments against increased nitrogen oxides and evaporative HC claims. Their method of testing vehicle emissions is an estimate based on all makes and models of vehicles, while no claim is made of differentiation between older and newer model cars. The proposed rule claims, "We estimate that the same amount of crude oil used to produce a BTU of gasoline can be used to produce 8 BTUs of ethanol. From a fuel utilization point of view, ethanol use can extend our domestic crude reserves by a factor of at least 8-to-1, or similarly reduce crude imports" (p. 11). The author found it difficult, at the least, to compare the BTU analysis written in this report with that of those found in earlier papers. All improvements in the calculations listed in government reports are based on estimates of state-of-the-art growing and processing facilities not in use.

It is not unrealistic to believe that technological advances improve production, but until proponents from both sides of the issue compare "apples to apples" the general public will always exhibit uncertainty about trusting what is supposed to published as fact.

Government scientists report, "If ethanol becomes a primary transportation fuel it will probably be made primarily from cellulosic crops like fast growing trees or woody plants" (Morris and Ahmed, 1992, p. 1). Irshad Ahmed is quoted as saying, "...the raw material will probably be cellulosic crops,

which have much better than a two-to-one net energy production" (Hoffman, 1994). A news release in the *Oil & Gas Journal* in August of 1994, headlined an article, "DOE: New process cuts ethanol cost." The National Renewable Energy Laboratory (NREL) in Golden, Colorado, announced a new process that will cut costs of producing ethanol from biomass to 60-70 cents per gallon from about $1.20 per gallon. The grain growers could be up against some extremely stiff competition.

The oil industry may be waging a new battle on the biomass front, only this time it looks like costs may be in the same ballpark.

THE DECISION-MAKING PROCESS

By looking at three different decision-making perspectives, economic and energy budgets of grain-based alcohol, or ethanol, can be examined for different possible outcomes from each perspectives. The first perspective is the traditional or classical decision-making process. The second perspective discusses value-focused thinking, and the third focuses on the holonomic best decision-making process.

Efficiently adaptive organizations embrace a decision-making process that includes "problem finding, problem formulation, due diligence, defining alternatives and outcomes, making a decision, effectively implementing the decision and auditing and controlling subsequent actions in order to make a significantly positive contribution to the goals" (Mackenzie, 1991, p. 228). These steps can be summarized as problem finding, problem formulation, decision making (techniques involved in selecting from among the alternatives), implementation, and audit and review.

TRADITIONAL DECISION-MAKING PROCESS

Traditional decision-making consists of selecting a choice which yields the highest value. It consists of assumptions of an objective function, a set of conditions, a consideration of various possible outcomes, techniques that permit the decision maker to select a preferred strategy or choice, and guidelines for the implementation of the strategy. Keeney (1992) describes it as: recognizing a decision problem, identifying alternatives, specifying values or objectives, evaluating alternatives, and selecting an alternative. Because automobile emissions and energy security are the two factors which led to the current ethanol debate, our government and its agencies looked toward existing technologies to solve these problems, as well as programs being implemented by States.

In the '70s, when these issues cropped up, environmental groups and disgruntled motorists who had to wait in long lines for gasoline, looked toward the government to fix the problems. The government looked around for existing solutions to air pollution problems and legislated decisions. They passed command-and-control regulations for automobile emissions (The Clean Air Act of 1977). Those who made these decisions were alienated from those who were to implement these decisions. The government also searched for existing solutions to make the nation less dependent on foreign oil--Nebraska's incentive for agricultural ethanol. The stage was set and when the EPA dropped the ball by overlooking applicable emissions standards in 1975, a powerful faction arose that would not be denied. Twenty years of tax exemptions and financial incentives where thrown into a process (ethanol production) that was costly to taxpayers and is currently questionable and surrounded with uncertainties.

The American public was bombarded with environmental doom through the media and wanted to believe that our problems were being solved. Our government rewards inefficient programs by giving them more money to meet their objectives, instead of pulling the plug on ineffective programs and freeing up monies that might allow effective change. Contracts are written with precise specifications that do not allow quick changes.

Time to analyze the situation is ultimately longer than the time over which the situation does not change. The whole process is reactive and corrective and assumes that the environment in which it operates does not change. There is no interaction between values and the creation of better alternatives from which to choose among. The decision was made that ethanol would solve our pollution and energy security problems based on values of special interest groups. Society believed the government knew what was best and went along with it. The alternatives from which to choose were too narrow and those making the decision were not the ones who would implement the decision. Ethanol production decisions were made without regard to higher elements such as strategic, tactical or operating plans. The quick ethanol fix decreased the efficiency of alternative options.

VALUE-FOCUSED THINKING

Keeney's (1992) book, *Value-Focused Thinking: A Path to Creative Decisionmaking,* points out that traditional decision-making is backwards. Unlike value-focused thinking, traditional decision-making focuses on first identifying existing alternatives. Value-focused decision-making centers on recognizing and articulating values and fundamental objectives to arrive at meaningful decisions through the creation of decision opportunities and better

alternatives. "Alternatives are the means to achieve the more fundamental values" (Keeney, 1992, p. 3). The notion is based on two activities: deciding what is wanted and then determining how to achieve it. Traditional decision-making starts with selecting from existing alternatives which limits the range of alternatives.

Value-focused decision-making creates or changes alternatives by indicating everything that is really cared about in the decision. It broadens the search for alternatives and win-win situations. These decision situations have three common characteristics: they are all based on real decisions, they are important to the person making the decision, and they are all complex decisions with no clear solutions. After determining the fundamental objectives, by qualitatively stating all that is of concern in the decision context, logical reasoning processes (quantitative modeling or analysis) are followed to determine the processes by which the fundamental objectives can be achieved.

Value-focused thinking offers many advantages: it improves communication by fostering participation and contributions from others involved, facilitates involvement in multiple-stakeholder decisions, guides information collection, uncovers hidden objectives, interconnects decisions so that the same set of objectives are achieved, aids in evaluating alternatives because the objectives are complete, creates alternatives, identifies decision opportunities or ways to improve existing situations, and guides strategic thinking. Value-focused thinking is proactive.

The activities associated with value-focused thinking are: recognize a decision problem, specify values, create alternatives, evaluate alternatives, select an alternative. In contrast to traditional decision-making, specifying values happens before identifying alternatives. Value-focused thinking then creates alternatives instead of identifying them. Another major difference is that

of creating decision opportunities or discovering ways to make situations better instead of accepting the status quo.

Some disadvantages to value-focused thinking are that it is really a specialized case of organizational problem-solving. Due to its technical nature, it looses its ability to generalize. Its focus is *alternative* generation geared to the decision-makers' or stakeholders' values and thus leaves out criteria for best-decision standards. Motivation of the decision maker needs to be questioned. The formulation does not provide for long-term analysis of what may be best for the decision-maker, so that the time over which the situation does not change is shorter than the time it takes to analyze the problem. It deals, to some extent, with problem finding, but mainly with problem formulation and decision making. It completely ignores the implementation and audit and review processes of decision-making.

Values and interests of the grain growing regions are reflected in the Clean Air Act, but all possible alternatives were not brought to the table. Legislation and regulations were rammed through Congress in hopes of providing a solution to energy security and air pollution problems based on future potential of estimated benefits, according to select interest groups. The production of ethanol as a solution to these two problems may not have been the solution a value-focused thinking decision may have uncovered. Many more alternatives would have been reviewed before the green light was given ethanol. Science was not allowed to help form alternatives, but was called upon to make the decision work after the fact.

THE HOLONOMIC BEST-DECISION MAKING PROCESS

The process view of decision-making aims at stabilizing the process of change, and consequently decision-making, by anchoring the decision to

strong values and clear strategic direction. Mackenzie (1991) reports that to stabilize the process of change, the process view of decision-making embraces the following three major elements.

1. *Scope of application*--the higher up in the organization, the greater the scope. Change at the highest level has far reaching effects, while change at the bottom has immediate effects.

2. *Locus of "rights reserved" to make adaptations in the levels of the organizational decision process*--different levels in the hierarchy have different decision-making responsibilities.

3. *Flexibility of change*--It is most difficult to make changes at the apex. Once it has made a decision, then a framework is established. The lower levels adjust and make implementation decisions within that framework to fit the necessary conditions.

The process view of organizational decision-making is structured on a bedrock of seven criteria for *best decision-making*: due diligence indicates that it is workable, the organization benefits, the harm to any stakeholder is minimized, it is the right thing to do, it is congruent with the strategic direction of the organization, and it is best for the organization (Mackenzie, 1991).

Best decision-making differs from traditional decision-making and value-focused thinking in that the decision process is spread throughout the organization and is not just the responsibility of the decision-maker. The implementors are not alienated from the decision-makers. This increases the power to initiate changes. The people who apply the decision determine effective adaptability by evaluating its application within the overall organizational mission and their individual functions.

This type of decision-making differs from the other two in that it depends on the involvement of the implementors. Adaptation to change is quick, interdependence uncertainty is reduced and suboptimization is avoided. It seeks to produce a decision that is right and smart and will opt for a right

decision over a smart one if this is the only choice. It ensures that a long-term perspective is obtained if it is strategically congruent with values. This perspective assumes a dynamic environment, it is proactive, continuous, and asks "how can we do this better."

Best decision-making differs from traditional decision-making alone in that it imparts values through the fundamental philosophies. Traditional decision-making argues for being smart rather than dumb and basically does not consider values in alternatives, resulting in quick fixes which decrease efficiency of operations.

Best decision-making differs from value-focused thinking alone in that value-focused thinking focuses mainly on problem formulation and decision making. The motivation of the value-focused decision maker may come into question because they are alienated from implementors and others with shared interdependencies.

If the holonomic process view of organizational decision-making had been deployed while decisions were being made about ethanol, the decision would not have been the same. The strategic direction was that air pollution was to be decreased. Environmental impacts of ethanol are uncertain but appear to be small. Since CO is becoming less of a problem, the benefits of CO reduction is small given CO is a problem only in selected areas at certain times of the year. Thus ethanol use does not achieve the strategic directive. The other strategic directive, energy security, is undetermined as well. There is no clear consensus. Studies exist which show both an estimated decreased dependence in foreign oil due to ethanol, as well as an increased dependence of foreign oil due to ethanol. It is not clear if ethanol is the correct decision. What is clear, however, is that other more effective measures are in place that

have accomplished both strategic directives, such as more fuel efficient and less polluting vehicles.

CONCLUSION

This analysis points to the conclusion that the holonomic best-decision making process would have prohibited the decision to produce ethanol if one considers the political system similar to that of an organization. But the fact remains that the political system is not similar to that of an organization. The main difference perceived by the author is stakeholder conflict. Even in the holonomic best-decision making process, stakeholders' values are identified and enfolded into the strategic direction. The problem with the political system is that the United States is made up of large regions with different sets of values. The grain producing regions band together and form strategic directions from values specific to them. The oil producing regions operate with different values which are embedded within their strategic directions.

All of the decision-making perspectives visited in this paper lack one thing in common--stakeholders do not extend to society as a whole. They are defined most broadly in the best-decision making view, but it defines them as groups of people or organized entities that are impacted by the decision. Society as a whole has no representation as a stakeholder. The whole of society has no one to speak for it. Some may argue that environmentalists speak for society, but in general their agendas have recently proven to be narrow and self-fulfilling. Taxpayers speak for society in a way, but this is a "hit and hope" voting process and it is continually doomed by party politics which are dictated by political action group interests.

Public policy issues, such as ethanol, need stakeholders defined in broad terms so that ethical decisions are ensured. One approach could

encompass the process view of organizational decision-making, and its best decision-making process, with *utilitarianism*. "Utilitarianism is an ethical theory that holds that an action is right if it produces, or it tends to produce, the greatest amount of good for the greatest number of people affected by the action. Otherwise the action is wrong" (DeGeorge,1990, p. 43). DeGeorge (1990) notes that when applying utilitarianism, all affected by the action must be carefully specified. Because acts are performed in social contexts, "Even those who are remotely affected, including business and society as a whole, should be specified" (p. 55). The social harm is a dominant consideration.

Public policy issues would arrive at different alternatives and decisions if ethical theory were incorporated into the decision-making process. In lieu of that, the next best thing is the best-decision making process.

REFERENCES

Anonymous. Doe: New process cuts ethanol cost. *Oil and Gas Journal*, **1994**, August 15, p. 48.

Anonymous. U.S. Agriculture Department sees $2 billion saving with ethanol-use. *PR Newswire*, **1994**, Washington, June 2nd.

Anonymous. More scientists are offering contrary views on the effectiveness and even safety of the U.S. program to require oxygenated fuels in 39 urban areas. *Oil and Gas Journal Newsletter*, **1993**, Vol. 91, No. 14, p. 4.

Austin, T.C., and C.S. Weaver. The air pollution consequences of using ethanol-gasoline blends in ozone non-attainment areas. *Sierra Research, Inc.*, Report No. SR89-05-01, **1990**.

Austin, T.C., and G. Rubenstein. Gasohol: Technical, economic, or political

panacea? *Society of Automotive Engineers*, **1981**, SAE Paper 800891, pp. 2681-2741.

Briggs, Michael. EPA ruling helps Illinois corn growers. *Chicago Sun-Times*, **1994**, Sunday News, p. 20.

DeGeorge, Richard T. *Business Ethics.* New York: Macmillan Publishing Company, **1990**, 486 pages.

Gething, J.A., J.S. Welstand, and J.C. Horn. Are the reductions in vehicle carbon monoxide exhaust emissions proportional to the fuel oxygen content? *Society of Automotive Engineers*, **1989**, SAE Trans. Paper 890216, *92,* pp. 179-192.

Hoffman, John. Biomass ethanol nears marketplace: New sources for ethanol fuel. *Chemical Marketing Reporter*, **1994**, *247*, No. 3, p. 3.

Kane, S., and M. LeBlanc. Ethanol and U.S. agriculture. *Agriculture Information Bulletin 559*, **1989**. USDA Economic Research Service.

Keeney, Ralph L. *Value-Focused Thinking. A Path to Creative Decisionmaking.* Cambridge: Harvard University Press, **1992**, 416 pages.

Mackenzie, Kenneth D. *The Organizational Hologram: The Effective Management of Organizational Change.* Boston: Kluwer Academic Publishers, **1991**, 493 pages.

Morris, David and Irshad Ahmed. How much energy does it take to make a gallon of ethanol? *Institute for Local Self-Reliance*, **1992**, 7 pages.

Nulty, Peter. Ethanol capers. *Fortune*, **1994**, *129*, No. 6, p. 14.

Pimental, D. Ethanol fuels: Energy security, economics and the environment. *Journal of Agricultural and Environmental Ethics*, **1991**.

Reddy, S.R. Evaporative emissions from gasoline and alcohol-containing gasolines with closely matched volatilities. *Society of Automotive*

Engineers, **1986**, SAE Trans. Paper 861556, *95*, pp. 6.760-6.778.

United States Department of Agriculture. Comments Concerning The Environmental Protection Agency's Regulation of Fuels and Fuel Additives: Renewable Oxygenate Requirement for Reformulated Gasoline Proposed Rule. Washington, DC: **1994**.

Walls, M.A., A.J. Krupnick, and M.A. Toman. Ethanol fuel and non-market benefits: Is a subsidy justified? *Resources for the Future*, **1989**, Energy and Natural Resources Division, Paper No. ENR-89-07, 28 pages.

Yaccarino, P.A. The effect of oxygenated fuel, altitude and temperature on CO emissions. *Society of Automotive Engineers*, **1989**, SAE Paper 892063.