OPPORTUNITIES FOR MINNESOTA
Ethanol Production for Fuel and Industrial Use

MARCH 4, 1983

PREPARED BY:

GOVERNOR'S ADVISORY COMMITTEE
ON AGRI-PROCESSING
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SUBCOMMITTEE REPORT

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Ethanol and Rural Energy Parks Subcommittee

FINAL REPORT

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I. EXECUTIVE SUMMARY

Production of ethanol and its byproduct high protein feed provides the most immediate and significant agri-processing opportunity for Minnesota. The Subcommittee recommends an aggressive and practical State program to capture these opportunities for Minnesota.

The production of ethanol from grain can be viewed from two important perspectives. First, ethanol production is a significant new addition to agri-processing. Minnesota needs new agri-processing facilities to process its agricultural crops into products of higher value to improve Minnesota's interstate balance of payments. Agri-processing no longer includes only foods, feeds and oils. A wide variety of chemicals can now be produced from agricultural crops for fuel and industrial uses. This creates an important new market for Minnesota agricultural products. Second, ethanol production is a major part of the emerging biomass energy technologies. Development of biomass energy is the State's most significant opportunity to decrease Minnesota's absolute dependence on imported energy. Minnesota has a serious need for both agri-processing plants and methods of energy production from State resources. Ethanol's ability to address both these critical needs makes this industry very important to Minnesota's future.

Minnesota needs an active economic development program which encourages the processing of the State's agricultural resources into products of higher value prior to export. This program must encourage the development of Minnesota's energy resources within the State. Development of the ethanol industry would strengthen Minnesota agriculture and benefit the State's high technology, manufacturing and construction industries. Most important, processing in Minnesota will improve our overall interstate balance of payments and return jobs and incomes to the State.

The petroleum shortages in the late 1970's created a great demand for Gasohol which used ethanol as a fuel extender for gasoline. The millions of miles driven on Gasohol proved in actual use in just a few years the value of ethanol not only as a fuel extender, but as a gasoline octane enhancer. Today, ethanol has been proven and approved as a widely applicable, cost effective, and environmentally safe octane enhancer.

Two recent U.S. Environmental Protection Agency (EPA) actions dramatically increase the opportunities of ethanol enhanced fuels. First, the new EPA lead phasedown regulations will require refiners to reduce total lead usage by over 34 percent on an industry-wide basis. In 1984 and 1985 alone, the required lead reduction of 7.1 and 11.9 billion grams is the octane equivalent of 1.42 and 2.38 billion gallons of ethanol, respectively (Herman & Associates). Second, the EPA has recently denied approval for use of methanol as an octane enhancer without co-solvents (the primary available co-solvent being ethanol). This leaves ethanol as one of the major proven environmentally safe octane enhancers available in sufficient quantity to replace lead enhancers. Of course, ethanol's fuel extending capabilities may once again prove extremely valuable should petroleum shortages reappear as the world-wide recession abates.

Over 100 ethanol plants have been built in the past 4 years, primarily in the Midwestern U.S., totaling nearly $1 billion of new plant construction (Information Resources, Inc.). Considering the depths of the recession over this period, this is a truly remarkable capital expansion. Also, considering the generally unfavorable position taken by the Federal Office of Management and Budget, this growth is extraordinary. Ethanol blended fuel sales are up over 160% in the past year despite declines in gasoline prices (Federal Highway Administration statistics). In addition to the broad based support from the agricultural community, major agri-business and energy companies are currently capturing the opportunities presented by this rapid growth industry in other states.

According to a report prepared by Resource Planning Associates, Inc., for the U.S. Department of Energy (DOE), the production of 50 million gallons of alcohol per year can result in an annual increase in Minnesota's economic activity of $241 million, and a net increase of $27.3 million in direct local, state and federal tax receipts. According to another study by Employment Research Associates, also prepared for the DOE, construction of processing plants to produce 50 million gallons of alcohol per year would result in roughly 1,330 construction jobs, 1,750 related industrial jobs, 325 jobs in the services sector, and 590 high quality full-time permanent operating and maintenance jobs - for a total of nearly 4,000 full-time positions.

These are dramatic economic impacts when the effect on a rural community is considered. This income will be spread throughout the community, from the local service station, the truckers, the family farm, local merchants, etc. Also, since many of the jobs are high quality technical and craft positions, these opportunities have considerable potential to stop the out-migration of youth from the rural community.

One of the most striking elements of this industry is that virtually none of this growth is taking place in Minnesota. Technically and economically this is difficult to explain. Many of the most active firms in the ethanol industry are headquartered or have major offices in the State. Many of the industry pioneers are from the State. Minnesota is a major grain producer. The State has abundant water, land, raw materials, infrastructure and transportation systems. Iowa, South and North Dakota are all the sites of major development. By all accounts, Minnesota should be a center of this industrial expansion. It appears that a major impediment to this industry's growth in Minnesota has been the lack of State sponsored incentives. The record would indicate that this lack of incentives has been a formidable barrier to the growth of this industry in Minnesota. The main focus of this Report is to lay the groundwork for an aggressive, yet practical, program to recruit this rapidly growing industry to Minnesota. In other words, it's time Minnesota got a "piece of the action".

C. SUBCOMMITTEE FINDINGS

As the following quote demonstrates, the need for development of an ethanol industry was apparent nearly 50 years ago:

> "We must alter our internal economy by processing surplus farm crops into alcohol to be mixed with gasoline in the proportion of 10 percent...We will be able to establish a balanced agriculture, a balanced industry and preserve for ourselves the greatest market in all the world, namely, the market in our own land for our own people. It is a kind of diversification through which we can preserve an internal prosperity and rid ourselves of a dangerous dependence on the other nations." (Representative Everett Dirksen (R-Ill), January 28, 1935, Congressional Record, Vol. 79, part 1, p.1099.)

IT IS THE UNANIMOUS CONCENSUS OF THE SUBCOMMITTEE THAT PRODUCTION OF ETHANOL AND ITS BYPRODUCT HIGH PROTEIN FEED PROVIDES THE MOST IMMEDIATE AND SIGNIFICANT AGRI-PROCESSING OPPORTUNITY FOR MINNESOTA. IT IS THE OVERALL OBJECTIVE OF THE SUBCOMMITTEE TO INITIATE AN AGGRESSIVE, YET PRACTICAL, STATE PROGRAM TO CAPTURE THESE OPPORTUNITIES FOR MINNESOTA.

The production of ethanol from grain can be viewed from two important perspectives. First, ethanol production is a significant new addition to agri-processing. Minnesota needs new agri-processing facilities to process its agricultural crops into products of higher value to improve Minnesota's interstate balance of payments. Agri-processing no longer includes only foods, feeds and oils. Now a wide variety of chemicals can now be produced from agricultural crops for fuel and industrial uses. This creates an important new market for Minnesota agricultural products. Second, ethanol production is a major part of the emerging biomass energy technologies. Development of biomass energy is the State's most significant opportunity to decrease Minnesota's absolute dependence on imported energy. Minnesota has a serious need for both agri-processing plants and methods of energy production from State resources. Ethanol's ability to address both these critical needs makes this industry very important to Minnesota's future.

MINNESOTA IS A STATE POOR IN FOSSIL FUELS. AS A RESULT, THE STATE IS HEAVILY DEPENDENT ON ENERGY PRODUCED BY OTHER STATES AND COUNTRIES. OUR LOCATION AT THE END OF THE ENERGY PIPELINE IS EXPECTED TO RESULT IN A DRAIN OF MORE THAN $460 BILLION FROM THE MIDWESTERN ECONOMY OVER THE NEXT FIVE YEARS AS A RESULT OF ENERGY IMPORTS. (MIDWEST GOVERNOR'S CONFERENCE-1982) THE MINNESOTA ENERGY AGENCY HAS ESTIMATED THAT THIS EXPORT OF FUNDS COULD COST APPROXIMATELY 95,000 FULL-TIME JOB EQUIVALENTS IN THE STATE OF MINNESOTA ALONE (MIDWEST GOVERNOR'S CONFERENCE-1982).

Minnesotans have already begun to feel the costs of high fuel bills, plant relocations, deferred plant expansions, and industries not opening new businesses in Minnesota. Businesses are directing their plant expansions to the energy-rich southern and western states. This exodus to energy-rich states has been elevated to crisis proportions by the perception of a difficult business climate in Minnesota.

AT THE SAME TIME THAT MINNESOTA IS LOSING INCOME, JOBS AND INDUSTRIAL GROWTH TO OTHER STATES, THE STATE IS ALSO NEGLECTING ITS OWN GREAT ENERGY POTENTIAL IN PRODUCING ENERGY FROM BIOMASS. Minnesota is rich in many forms of biomass, such as agricultural crops, agricultural and forest residues, and peat. It is important to understand that many products that can be produced from petroleum can be produced from biomass. It is simply the relationship of the cost of raw materials to the cost of processing the raw materials into products that determines which technology dominates the production of a particular product. This relationship has already turned in favor of production of ethanol, n-butanol, isopropyl, and acetone from biomass rather than the conventional method using petroleum and natural gas. There are many other chemicals and fuels which may also have great potential to be produced from biomass. Converting Minnesota's biomass resources with existing or developing technologies will give the State the capacity to produce a significant portion of its own energy needs while developing additional products for export. It only requires the application of new technology and capital to produce many additional products from biomass.

Unless the State develops a strong agri-processing program, Minnesota will continue to act as an underdeveloped country by shipping out raw materials to be processed into products of higher value elsewhere. As a result, the economic, social and political advantages of the prosperity generated from this value-added processing will be increasingly lost by Minnesota and its citizens.

The State contains the headquarters for many corporations capable of sponsoring major ethanol and other agri-processing facilities. However, these companies have located processing facilities elsewhere in recent years. A careful examination of two of Minnesota's three resource based industries, agriculture and mining, shows that major companies in these industries have become largely transportation companies. Most of Minnesota's major grain and mining companies are primarily dedicated to move the raw materials out of the state with as little processing as possible.

There is a general feeling that Minnesota's problems are temporary and simply a subset of the Nation's economic problems. Clearly, the worldwide recession has hit Minnesota. However, the loss of raw material processing industries represents a fundamental structural shift in the State economy. One clear example is how poorly the State has weathered this recession relative to previous national recessions. Analysis shows that with each successive economic cycle, Minnesota's ability to resist economic downturn has declined.

As of January, 1983, 32 states have some form of excise tax exemption for ethanol/gasoline blends ranging from 1¢ per gallon in Connecticut to 10¢ per gallon in New Mexico. As of August, 1980, nine states provided some type of sales tax forgiveness on sales of ethanol/gasoline blends. Also, nine states provide property tax deductions or exemptions. Four states provide income tax credits. Minnesota provides none of these benefits. The lack of these incentives has put Minnesota at a severe competitive disadvantage and has stunted the growth of this industry in Minnesota.

In addition, plants considering Minnesota locations face higher capital costs due to sales tax on process equipment and higher taxes on construction labor, higher business taxes, inflexible environmental regulation, shortages of capital, and a lack of coordinated state agency review and support. For example, a total of 33 different permits with 21 different state and federal agencies are required of an ethanol project in Minnesota. Anything less than the most cooperative and supportive agencies results in extreme difficulty in completing the permitting process. Certain State agencies have clearly demonstrated a less than enthusiastic support for ethanol plant development in Minnesota.

The Subcommittee recommends that the Minnesota Legislature pass legislation to support the following four needs of the ethanol industry:

- 1) provide excise tax exemption for ethanol/gasoline blends,
- 2) establish a loan guarantee program for plants built in the State,
- 3) establish a permit expediting authority (or Ombudsman) to support firms planning new facilities in the State, and
- 4) provide sales tax forgiveness for major process equipment installed in the ethanol plant.

The excise tax exemption should provide a 4¢ per gallon exemption for gasoline/ethanol blend patterned after the federal law. This exemption should be phased into effect with a 2¢ exemption starting as soon as possible and an additional 2¢ starting two years later. The phasing of the exemption will minimize the impact of imported ethanol in the State and allow Minnesota's own industry the incentive and the time to catch up with other states. The loan guarantee program should establish a $20 million reserve fund that can be leveraged through investor equity and private debt to develop $130 million in ethanol projects. The permit expediting authority will not relax environmental regulations, but will accelerate the review process and reduce many of the bureaucratic barriers facing developers. A limited sales tax exemption should be granted on main process equipment permanently installed in the plant. This is similar to the real estate exemption.

Implementation of the Subcommittee's recommendations will allow the State to capture the substantial opportunities presented by this new rapid growth industry.

II. INTRODUCTION

A. PREFACE

In January, 1983 Minnesota Governor Perpich appointed a special commission on agricultural processing to make recommendations for a State program to support the development of agri-processing plants in Minnesota. The Commission, Chaired by Ralph Hofstad of the Land O' Lakes Cooperative, established a subcommittee to investigate processing Minnesota agricultural crops into ethyl alcohol (ethanol) for fuel and industrial use. The Subcommittee was also to assess the feasibility of rural energy parks. The Ethanol and Rural Energy Parks Subcommittee is chaired by Burton M. Joseph, President of I.S. Joseph Company. The Subcommittee is comprised of senior members of Minnesota's farm cooperatives and agri-processors, the Governor's office, and Minnesota based research, engineering and construction firms (see Appendix D for brief background of Subcommittee members).

The focus of this Subcommittee Report is ethanol production from grain. The Subcommittee did not consider Rural Energy Park development in this Report due to the urgent need for information regarding pending ethanol legislation. Consideration of Rural Energy Park development will be the subject of future Subcommittee study.

B. OBJECTIVES OF SUBCOMMITTEE AND REPORT

The objectives of the Subcommittee were determined to be threefold. First, to examine the opportunities in Minnesota for ethanol production from agriculture. Second, to provide basic information about the ethanol industry to the agricultural, political and business leaders of the State. Third, make specific recommendations for legislative and administrative action by the State to capture these opportunities for Minnesota.

The Subcommittee Report which follows identifies the opportunities for Minnesota, provides an economic and financial analysis of ethanol production, analyzes the need for a State participation in development of this industry, and makes specific recommendations for a Minnesota program. The appendices contain responses to the most frequently asked questions regarding the ethanol industry, a description of a typical ethanol plant and the Report Bibliography.

MINNESOTA NEEDS AN ECONOMIC DEVELOPMENT POLICY WHICH ENCOURAGES THE PROCESSING OF MINNESOTA RESOURCES TO PRODUCTS OF HIGHER VALUE PRIOR TO EXPORT. THIS MUST ALSO BE A POLICY WHICH ENCOURAGES THE DEVELOPMENT OF MINNESOTA'S ENERGY RESOURCES WITHIN THE STATE. SUCH A POLICY WILL HELP RETURN MINNESOTA'S ECONOMY TO A POSITION OF STRENGTH AND PROSPERITY. Development of an ethanol industry could substantially strengthen agriculture, which is an historic mainstay of the Minnesota economy. Development of the ethanol industry in Minnesota will also benefit the State's high technology and construction industries, and strengthen our overall inter-state balance of payments. Minnesota's response to the opportunities presented by the ethanol industry is a test case of the State's resolve to reverse this trend toward economic obscurity.

D. OPPORTUNITIES FOR MINNESOTA

The petroleum shortages in the late 1970's created a great demand for Gasohol which used ethanol as a fuel extender for gasoline. The millions of miles driven on Gasohol proved in actual use in just a few years the value of ethanol not only as a fuel extender, but as a gasoline octane enhancer. The Gasohol movement, largely supported by American agriculture, saved perhaps 10 or more years of necessary testing and permitting to have ethanol established as a main line octane enhancer. Today, ethanol has been proven and approved as a widely applicable, cost effective, and environmentally safe octane enhancer.

THE CRITICAL NEED TO REDUCE LEAD AS AN OCTANE ENHANCER IN GASOLINE HAS CREATED A SUBSTANTIAL OPPORTUNITY FOR ETHANOL USE AS AN OCTANE ENHANCER. Ethanol's gasoline octane enhancing market is distinctly different from the Gasohol's gasoline extender market. Ethanol as an octane enhancer is valuable even in times of petroleum surplus.

TWO RECENT U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) ACTIONS DRAMATICALLY INCREASE THE OPPORTUNITIES OF ETHANOL ENCHANCED FUELS. FIRST, THE NEW EPA LEAD PHASEDOWN REGULATIONS WILL REQUIRE REFINERS TO REDUCE TOTAL LEAD USAGE BY OVER 34 PERCENT ON AN INDUSTRY-WIDE BASIS. In 1984 and 1985 alone, the required lead reduction of 7.1 and 11.9 billion grams is the octane equivalent of 1.42 and 2.38 billion gallons of ethanol, respectively (Herman & Associates). Second, the EPA has recently denied approval for use of methanol as an octane enhancer without cosolvents (the primary available cosolvent being ethanol). THIS LEAVES ETHANOL AS ONE OF THE MAJOR PROVEN ENVIRONMENTALLY SAFE OCTANE ENHANCER AVAILABLE IN SUFFICIENT QUANTITY TO REPLACE LEAD ENHANCERS. Of course, ethanol's fuel extending capabilities may once again prove extremely valuable should petroleum shortages reappear as the world wide recession abates.

OVER 100 ETHANOL PLANTS HAVE BEEN BUILT IN THE PAST 4 YEARS, PRIMARILY IN THE MIDWESTERN U.S., TOTALING NEARLY $1 BILLION OF NEW PLANT CONSTRUCTION (Information Resources, Inc.). Considering the depths of the recession over this period, this is a truly remarkable capital expansion. Also, considering the generally unfavorable position taken by the Federal Office of Management and Budget, this growth is extraordinary. ETHANOL BLENDED FUEL SALES ARE UP OVER 160% IN THE PAST YEAR DESPITE DECLINES IN GASOLINE PRICES (Federal Highway Administration statistics). In addition to the broad based support from the agricultural community, major agri-business and energy companies are currently capturing the opportunities presented by this rapid growth industry in other states.

According to a report prepared by Resource Planning Associates, Inc., for the U.S. Department of Energy (DOE), THE PRODUCTION OF 50 MILLION GALLONS OF ALCOHOL PER YEAR CAN RESULT IN AN ANNUAL INCREASE IN MINNESOTA'S ECONOMIC ACTIVITY OF $241 MILLION, AND A NET INCREASE OF $27.3 MILLION IN DIRECT LOCAL, STATE AND FEDERAL TAX RECEIPTS. According to another study by Employment Research Associates, also prepared for the DOE, CONSTRUCTION OF PROCESSING PLANTS TO PRODUCE 50 MILLION GALLONS OF ALCOHOL PER YEAR WOULD RESULT IN ROUGHLY 1,330 CONSTRUCTION JOBS, 1,750 RELATED INDUSTRIAL JOBS, 325 JOBS IN THE SERVICES SECTOR, AND 590 HIGH QUALITY FULL-TIME PERMANENT OPERATION AND MAINTENANCE JOBS - FOR A TOTAL OF NEARLY 4,000 FULL-TIME POSITIONS.

These are dramatic economic impacts when the effect on a rural community is considered. This income will be spread throughout the community, from the local service station, the truckers, the family farm, local merchants, etc. Also, since many of the jobs are high quality technical and craft positions, these opportunities have considerable potential to stop the out-migration of youth from the rural community.

Until three years ago, the industry was dominated by small "grass roots" local developers who were generally under-capitalized and highly-leveraged. A major impediment to an even more rapid expansion of the industry has been this grass roots nature of many of the developers. If these developers could generate the hundreds of projects formed in these early years, the results are expected to be impressive with stronger corporate entities entering the industry. In the last three years, several agri-processing and energy firms have ventured into ethanol production. Table II-1 contains a list of major corporations that are already investors in the fuel and industrial ethanol industry.

TABLE II-1

MAJOR CORPORATE PARTICIPANTS
IN THE ETHANOL INDUSTRY

Firm	Involvement
Texaco Oil Company	Co-owner of 50 million gallon per year (mmgpy) plant in Pekin, Illinois.
Ashland Oil Company	Co-owner of 60 mmgpy plant in South Point, Ohio. Announced plans for another 60 mmgpy plant in a location to be announced (Minnesota is being considered).
Publicker Industries	Co-owner of 60 mmgpy plant in South Point, Ohio.
Ohio Farm Bureau	Co-owner of 60 mmgpy plant in South Point, Ohio.
Chevron Oil Company	Co-owner of a 50 mmgpy plant under construction in Kentucky.
Corn Products Company (CPC International)	Co-owner of 50 mmgpy plant operating in Pekin, Illinois.
Archer Daniels Midland	Owns and operates 220 mmgpy of plant capacity in Illinois and Iowa.
A.E. Staley	Owner of 50 mmgpy plant recently completed in Loudon, Tennessee.
E.F. Hutton	Raised over $30 million and invested $15 million of own funds for co-ownership in the 50 mmgpy plant in South Bend, Indiana.
Midwest Solvents	Operates plants in Atchison, Kansas and Pekin, Illinois producing 20 mmgpy.
Kentucky Farm Bureau	Co-owner of Chevron Oil Plant at Franklin, Kentucky.

All of the plants listed in Table II-1 relied on State and Federal supports including energy tax credits, loan guarantees, excise tax exemptions and project development support from local authorities. These projects are now commercially successful businesses providing jobs, income and taxes for the community. Other major corporations such as Cargill, Peavey, U.S. Industrial Chemicals, and Union Carbide are known to be considering building similar plants in states other than Minnesota.

The following quote from a February 17, 1983 Minneapolis Star & Tribune article on Ashland Oil's consideration of a plant in Minnesota exhibits the importance of a Minnesota support program; "Ashland Oil, Inc. is considering building a $140 million ethanol plant in Washington County...The Ashland facility would create a new market for 24 million bushels of corn a year and would generate 500 construction jobs and 200 permanent jobs. In its first year alone, the state would harvest $7 million in state sales taxes...A key component of the discussions has been the possibility of state-backed loan guarantees."

All of the ethanol plants owned by major companies are successfully operating and profitable. Even a majority of the smaller poorly constructed, under-capitalized projects continue to operate. It is estimated that over 50 major projects (each exceeding $20 million in capital cost) are currently in the final planning stages (USDA, DOE and miscellaneous industry sources). ETHANOL PRODUCTION IS EXPECTED TO INCREASE TEN FOLD FROM THE CURRENT 225 MILLION GALLONS TO 2 BILLION GALLONS OVER THE NEXT FOUR YEARS. Actual production figures are always considerably less than plant capacity figures since the ethanol production capacity of corn wet milling plants is idle during much of the year while the corn starch is converted into other products such as fructose sugar. Anyone would be hard pressed to name another industry that has shown such growth over the past four years.

However, one of the most striking elements of this industry is that virtually none of this growth is taking place in Minnesota. Technically and economically this is difficult to explain. Many of the most active firms in the ethanol industry are headquartered or have major offices in the State. Many of the industry pioneers are from the State. Minnesota is a major grain producer. The State has abundant water, land, raw materials, infrastructure and transportation systems. Iowa, South and North Dakota are all the sites of major development. By all accounts, Minnesota should be a center of this industrial expansion. IT APPEARS THAT A MAJOR IMPEDIMENT TO THIS INDUSTRY'S GROWTH IN MINNESOTA HAS BEEN THE LACK OF STATE SPONSORED INCENTIVES. THE RECORD WOULD INDICATE THAT THIS LACK OF INCENTIVES HAS BEEN A FORMIDABLE BARRIER TO THE GROWTH OF THIS INDUSTRY IN MINNESOTA.

The ethanol industry has proven itself technically and financially in the short-run and is rapidly proving itself in the long-run. There is little any governmental program can do in the long run to distort the fundamental economics of an industry. In the case of ethanol production, the fundamental economics are being proven every day.

However, a governmental program can impact the timing and location of new commercial development. MINNESOTA CAN DEVELOP A PROGRAM TO ACCELERATE THE GROWTH OF THIS INDUSTRY AND INSURE ITS LOCATION IN MINNESOTA. THE MAIN FOCUS OF THIS REPORT IS TO LAY THE GROUNDWORK FOR AN AGGRESSIVE, YET PRACTICAL, PROGRAM TO RECRUIT THIS RAPIDLY GROWING INDUSTRY TO MINNESOTA. IN OTHER WORDS, IT'S TIME MINNESOTA GOT A "PIECE OF THE ACTION".

E. ETHANOL IN PERSPECTIVE

It is important to realize that ethanol is not a "flash-in-the-pan" remnant of the energy crisis. Ethanol production is the first step in a greatly expanded agri-processing and biomass energy program for Minnesota.

It is widely recognized that industrialized and developing economies desperately require fuels, chemicals and protein feeds. These chemicals and fuels are often referred to as petrochemicals. Petrochemicals are used in chemical products such as plastics, printing inks, paints, solvents, etc., and as liquid fuels, such as gasoline and diesel fuel. Protein feeds come in the form of animal, grain or processed proteins. Protein feeds can be used for feeding livestock, such as cattle, hogs, and poultry, and as human consumable protein supplements and substitutes.

The long term price instability and uncertain availability of petroleum and natural gas, coupled with growing world hunger, has created a substantial opportunity to capitalize on the microbiological conversion of carboyhdrates (in the form of renewable biomass) into fuels, chemicals and protein feeds. The production of ethanol from carbohydrate crops, such as corn, is one form of biomass energy. There are over 20 major industrial chemicals which can be produced by the microbiological conversion of carbohydrates (see Figure II-1 and Table II-2).

FIGURE II-1

CHEMICALS FROM CORN

This advertisement appearing in chemical industry magazines represents a major effort to market carbohydrates as a substitute feedstock for petroleum. The advertisement summarizes the chemical industry's emerging view of opportunities facing bioindustrial chemical technologies. (Reprinted by permission of Trout and Ries Advertising.)

TABLE II-2

CHEMICALS FROM FERMENTATION PROCESSES

CHEMICAL	CHEMICAL
Ethanol	Methanol
N-Butanol	Gluconic acid
2.3-Butylene glycol	2-Keto-gluconic acid
Glycerol	Itaconic acid
Acetic acid	Tartaric acid
Acetone	Pyruvic acid
Isopropanol	d-Keto-glutaric acid
Fumaric acid	L-Isocitric acid
Succinic acid	L-Alloisoacetic acid
Citric acid	5-Keto-gluconic acid
Lactic acid	D-Araboascorbic acid
Propionic acid	Koji acid
Malic acid	D-Xylonic acid

Carbohydrates can be found in all forms of plant material, such as grains and other crops, agricultural residues, food processing wastes, forest residues, etc. After processing, carbohydrates can be substituted for petroleum as a feedstock (raw material) in the production of many fuels and chemicals. Also, the byproducts of carbohydrate processing are high protein feed products. These high protein feeds provide as much, or more, food value as the original feedstock when combined with animal feed rations. As a result, the ability of carbohydrate conversion technologies to replace many petroleum conversion technologies presents an unprecedented opportunity to meet the most pressing energy and nutritional needs of the future. (See Figure II-2 and II-3)

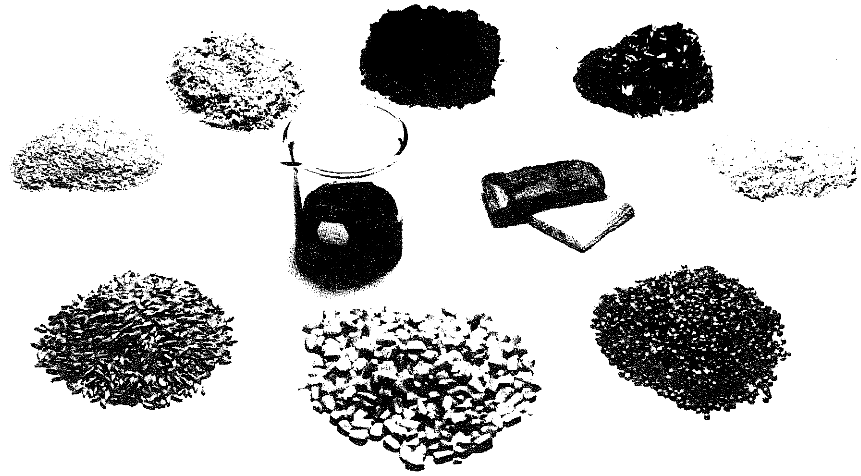


FIGURE II-2 - Several sources of carbohydrates (Clockwise from the top) - peat, sunflower hulls, rice hulls, grain sorghum (milo), corn, barley, flour mill waste, sawdust; Center) - molasses and wood chips.

FIGURE II-3 - Several uses of bioindustrial products. Shown are ethanol uses such as printing ink, vinegar, hairspray, industrial solvents, photographic supplies, gasoline octane enhancers, toiletries and other general chemical uses. Also shown are corn oil, yeast, protein feed, CO_2 and fructose (used in soft drinks) which are a few of the many valuable co-products of bioindustrial process technologies.

In addition, greatly expanded technical opportunities will result from genetic engineering developments in the microbiological conversion process. These biotechnology developments are rapidly creating new enzymes and micro-organisms capable of inexpensively converting carbohydrates to a variety of fuels, chemicals and protein products. The biotechnology industry already has a good start here in Minnesota. The University of Minnesota is very active in biotechnology and several new biotechnology firms are located in the State.

Biomass conversion technologies are already making steady inroads into the world energy stream. Biomass boilers are commonplace in the forest products industry. In just four years, use of liquid fuels from biomass has grown to represent over 2% of our Nation's fuel supply. Further, biomass derived ethanol is virtually eliminating petroleum derived ethanol in the industrial chemical market. Currently, biomass conversion technologies are estimated to produce as much useful energy as nuclear power. (DOE Report to Congress, 1982)

The uncertain supply of petroleum signals the beginning of an age of capital investment in new energy conversion processes. There has never been a energy shortage, or a shortage of raw materials for energy production in this Country. There is a shortage of processing plants required to produce liquid fuels and chemicals from the abundant sources of hydrocarbons available in the form of renewable biomass.

The choice facing the Minnesota and the U.S. is to anticipate the capital formation needs and to structure a smooth transition from absolute petroleum dependence. The various governmental bodies of the U.S., including the State of Minnesota, can act to insure that this alternative energy conversion capital formation takes place in a timely and orderly fashion.

In conclusion, the establishment of an ethanol production industry in Minnesota is the first step in developing a biomass energy program and an expanded agri-processing industry. THE POTENTIAL FOR IMPROVING THE STATE'S BALANCE OF PAYMENTS, MINIMIZING THE STATE'S DEPENDENCE ON IMPORTED ENERGY, AND CREATING A WIDE DIVERSITY OF PROCESSING INDUSTRIES IN THE STATE PROVIDES STRONG IMPETUS FOR AN ACTIVE STATE INCENTIVE PROGRAM. THIS WILL BE ACCOMPLISHED WHILE CONTINUING TO EXPORT PROTEIN FEEDS AND REVITALIZING THE FARM ECONOMY. OTHER BENEFITS INCLUDE USE OF AVAILABLE TECHNOLOGY, PROVEN COMMERCIAL VIABILITY, MINIMUM ADVERSE ENVIRONMENTAL CONSEQUENCES, AND THE USE OF RENEWABLE RESOURCES. CLEARLY, THERE IS MUCH MORE TO ETHANOL PRODUCTION THAN ENVISIONED BY THE GASOHOL MOVEMENT.

III. ETHANOL MARKETING & PRODUCTION ECONOMICS

A. MARKETING OF ETHANOL AND BYPRODUCTS

In order for an ethanol production venture to be successful, a thorough analysis of the potential markets for all products produced at the plant is required. Dry milling ethanol plants produce three major marketable products; ethanol, high protein feed, and carbon dioxide.

THE DEMAND FOR ETHANOL ON A NATIONWIDE BASIS HAS INCREASED MORE THAN 160% OVER THE LAST 12 MONTHS DUE TO AN INCREASE IN THE DEMAND FOR PREMIUM OR OCTANE ENHANCED UNLEADED FUELS WHICH USE ETHANOL, AND DUE TO AN INCREASE IN THE FEDERAL EXCISE TAX EXEMPTION ON AGRICULTURALLY DERIVED ETHANOL (FROM $.04/GAL. TO $.05/GAL.). ETHANOL INCREASES THE OCTANE RATING OF UNLEADED FUEL FROM 88 TO 91, THUS PERMITTING IT TO BE MARKETED AS "UNLEADED PREMIUM" OR "SUPER UNLEADED". THERE WILL ALSO BE FURTHER INCREASES IN DEMAND RESULTING FROM RECENT EPA LEAD PHASEDOWN REGULATIONS.

The most recent EPA lead phasedown regulations would require 20 billion gallons of ethanol over the next 8 years based on octane equivalent of the displaced lead. Other octane enhancers, such as benzene, xylene and toluene will make up much of the octane deficit created by lead phasedown. However, it is estimated that a new market for at least 1.5 billion gallons of ethanol per year has been created by EPA lead phasedown regulations (Texaco and Herman & Associates)

THE FEDERAL AND STATE PRICE SUPPORTS IN THE FORM OF GAS TAX EXEMPTIONS PROVIDE A PRICE ADVANTAGE FOR ETHANOL OVER COMPETING OCTANE ENHANCERS IN THE PRODUCTION OF HIGH OCTANE UNLEADED GASOLINE. Figure III-1 indicates how demand for ethanol/gasoline blended fuels has increased in the past two years.

Nationwide ethanol production capacity is approximately 225 million gallons per year, with an estimated 557 million gallons of capacity currently under construction. Minnesota currently has less than 2.0 million gallons/year of fuel grade ethanol production capacity with no additional plants under construction, although some 54 million gallons/per year of capacity is in the planning stage awaiting financing.

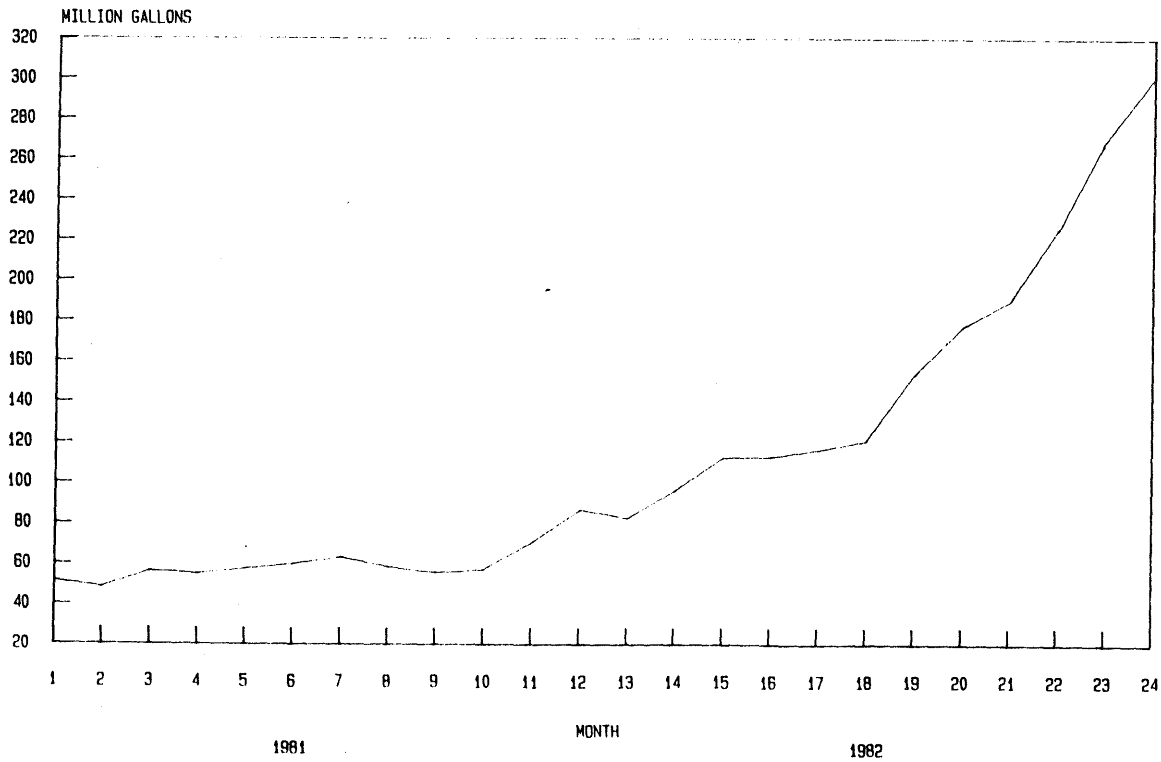
WHILE MINNESOTA HAS A LARGE GASOLINE MARKET (2 BILLION GALLONS/YEAR) IT IS ONE OF THE FEW MAJOR AGRICULTURAL STATES WHICH DOES NOT CURRENTLY PROVIDE ANY GASOLINE TAX EXEMPTIONS FOR FUEL GRADE ETHANOL. The State previously had a 4¢/gallon exemption which was struck down by the Supreme Court in 1982, since it restricted the exemption to Minnesota produced ethanol. Since most gasoline/ethanol blends are marketed on a 9 to 1 ratio of regular unleaded to ethanol, every 1¢/gal. tax exemption for gasoline/ethanol blends (state or federal) provides a 10¢/gal. price support for ethanol. With the average wholesale market price of ethanol at $1.70/gal. and the average wholesale price of regular unleaded gasoline at $.90 there currently exists an 80¢ per gallon price differential between ethanol and unleaded gasoline. Since ethanol is only 10% of gasoline/ethanol blends, an 80¢ ethanol gasoline price differential results in only an 8¢ price differential between gasoline/ethanol blends and competing premium unleaded without ethanol.

A combined state and federal tax exemption for gasoline/ethanol blends will make them competitive with premium unleaded without ethanol in the short-term while unleaded gasoline is less costly than ethanol. Industry experts believe that this differential will disappear as gasoline prices rise in the end of the decade and technical advances and adequate grain supplies keep ethanol prices constant or declining. This is the reason most excise tax exemptions for gasoline/ethanol blends are scheduled to be eliminated in the late 1980's or early 1990's. By providing these price supports, the government is effectively anticipating these gasoline price increases and enabling an alternative source of liquid fuels to be in place and fully operational.

A State excise tax exemption is recommended to stimulate the market for ethanol in Minnesota. With a 5¢ excise tax exemption provided by the federal government, a 4¢ State excise tax exemption will provide the necessary market incentive for ethanol blends in Minnesota. The total of 9¢ state and federal excise tax exemption will eliminate the 8¢ differential, plus provide an additional 1¢ to stimulate and accelerate industry growth in Minnesota.

FIGURE III-1
ETHANOL/GASOLINE BLEND SALES

1981 & 1982



Gasoline consumption in Minnesota averages about 2 billion gallons annually (State Energy Information Center). Table III-1 indicates the potential market penetration of ethanol/regular unleaded blends which could be purchased by blenders and refiners for octane enhancement and the ethanol production required to meet this market. This growth in market share is consistent with ethanol market penetration in states such as Iowa, which already support ethanol use. It should be noted that demand for ethanol will be further stimulated by an increased phasedown of leaded fuel use being mandated by the EPA.

TABLE III-1

MINNESOTA ETHANOL MARKET SHARE AND PRODUCTION REQUIREMENTS

Year	Potential Market Shares: % of All Gasoline/ Ethanol Blends Pre Lead Removal	% of Gasoline/ Ethanol Blends Post Lead Removal	Ethanol Required (Production in million gallons)
1984	10%	15%	20 to 30
1985	20%	25%	40 to 50
1986	30%	35%	60 to 70
1987	35%	40%	70 to 80
1988	40%	45%	80 to 90

The other major byproduct of the dry milling process is distillers dried grain and solubles (DDGS). This material is considered a medium grade protein feed (28% to 30% protein - soymeal is 44% protein) for all forms of livestock, but is primarily fed to ruminant animals due to its relatively high fiber content. It compares favorably with soybean meal on a nutritional basis and thus can currently be sold for about $150/ton. Regional, national and export markets exist for DDGS. Export markets have been particularly favorable in pricing. With the Mississippi River and Great Lakes transportation systems available to Minnesota, overseas trade for DDGS ranks high.

A third potential byproduct of the fermentation process is carbon dioxide (CO_2), which can be marketed as an industrial chemical, beverage ingredient, refrigerant, and may have potential as a growth stimulant for certain types of greenhouse plants. Raw CO_2 sells for approximately $6-10/ton with processed CO_2 selling for $45-$100/ton. However, a medium size ethanol plant generally cannot justify installation of CO_2 processing facilities. CO_2 recovery and marketing from medium size ethanol plants is very location sensitive, and thus CO_2 should be considered a marginal byproduct.

OVERALL, THE MARKET POTENTIAL FOR ETHANOL APPEARS TO BE STRONG, GIVEN APPROPRIATE TEMPORARY TAX EXEMPTIONS. THESE INCENTIVES ARE NEEDED TO BOTH ESTABLISH A MARKET FOR FUEL ETHANOL, AND TO PROVIDE NECESSARY INCENTIVES FOR POTENTIAL INVESTORS IN ETHANOL PRODUCTION FACILITIES. THE FEDERAL EXEMPTION ON AGRICULTURALLY DERIVED ETHANOL HAS BEEN EXTENDED TO 1992 AND MANY STATE INCENTIVES ARE CONCURRENT WITH THE FEDERAL PROGRAM (SEE SECTION IV). WHEN THE TAX INCENTIVES EXPIRE, THE MARKET FOR ETHANOL WILL THEN DEPEND ON THE GASOLINE AND RAW MATERIAL PRICES WHICH EXIST AT THAT TIME. IN THE INTERIM, THE POTENTIAL EXISTS FOR IMPROVING THE EFFICIENCY OF THE ETHANOL PROCESS AND THE DEVELOPMENT OF CHEAPER FEEDSTOCKS, PRIMARILY CELLULOSE, WHICH COULD ENABLE ETHANOL TO REMAIN COMPETITIVE WITH PETROLEUM BASED FUELS WITHOUT THE TAX INCENTIVES.

B. PRODUCTION ECONOMICS

The current primary feedstock for the production of ethanol is corn. The production of ethanol from corn is generally achieved via either wet milling or dry milling of the grain to separate the fermentable material from other byproducts. Wet milling plants tend to be large fully integrated plants capable of producing a wide variety of products based upon the market potential of each. Such plants tend to be capital intensive and highly site sensitive relative to raw materials and markets. In general, the economies of scale of wet milling plants dictate a minimum annual production capacity of 20 million gallons of ethanol per year in order to be competitive.

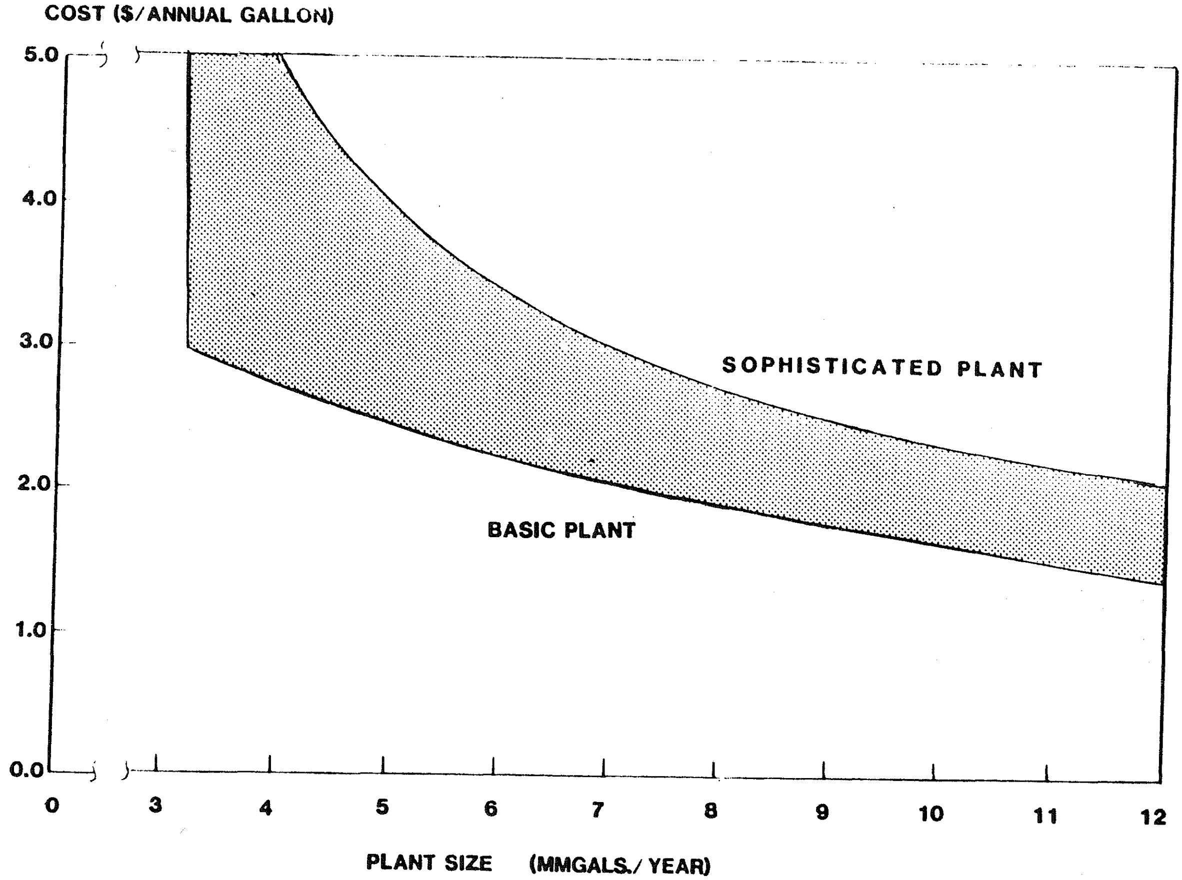
Dry corn milling ethanol plants tend to be smaller and less complex than wet milling plants, and are not as sensitive to location. Besides ethanol, the primary byproducts of dry milling are distillers dried grains and solubles (DDGS) and carbon dioxide. These plants generally range in production capacity from 4 to 20 million gallons per year.

Dry milling plants are considered a more likely candidate for development in Minnesota due to their greater versatility as to location, feedstock flexibility, and potential access to local cash grain markets and other lower cost feedstocks. Dry corn milling ethanol plants can vary greatly in capital cost according to plant capacity and sophistication. Figure III-2 indicates the range of estimated capital cost per annual gallon of production capacity as a function of plant size and complexity. In general, the complexity of a plant will depend on: 1) how the byproducts are to be recovered and marketed; 2) whether or not there are existing infrastructures such as grain handling and storage facilities; 3) what type of primary fuel is to be used in the plant; 4) materials of construction; and 5) type of controls used to operate the plant.

The lower line in Figure III-2 would be the average cost for a basic ethanol plant with carbon steel surfaces, a gas/oil boiler, no solubles recovery or drying equipment, and simple controls. The upper line indicates the average cost of a sophisticated ethanol plant with stainless steel surfaces, a coal boiler, DDGS drying, and solubles recovery system. In most cases the sophisticated plants show greater profitability in plant sizes above 5 million gallons due to lower operating costs and higher byproduct revenues.

FIGURE III-2

PLANT COST VS. SIZE



Tables III-2 through III-5 provide cost estimates for "typical" 5 and 10 million gallon per year ethanol plants. The capital cost estimates were based on equipment and facilities necessary to construct an operating ethanol plant capable of producing anhydrous ethanol and associated byproducts. The construction cost estimates include both the direct and indirect costs associated with project construction. Contractors fees, field offices, mobilization, etc., are the indirect costs incurred during construction. Capital costs for the 5 million gallon per year plant are itemized in Table III-2 and are summarized in Table III-3. Capital costs for the 10 million gallon plant are itemized in Table III-4 and are summarized in Table III-5.

TABLE III-2

EQUIPMENT INSTALLATION COST SUMMARY
5 MM GALLON PER YEAR FUEL GRADE ETHANOL FACILITY
(Labor & Materials)

DESCRIPTION (EXAMPLE ONLY)	COST
Equipment	
Section 01 - Grain Storage & Handling	$ 353,400
Section 02 - Cooking Process	100,300
Section 03 - Hydrolysis	153,800
Section 04 - Fermentation	1,065,000
Section 05 & 06 - Binary Distillation and Dehydration	1,195,700
Section 07 - Liquid Solid Separation	392,000
Section 08 - Evaporation	542,000
Section 09 - Drying/Pelletizing	406,100
Section 10 - Denaturant/Ethanol Storage	132,000
Section 11 - DDGS Storage & Handling	127,000
Section 12 - Miscellaneous	393,000
Section 13 - Energy System	1,010,000
Total Equipment (Inc. Freight)	$ 5,870,300
Equipment Erection	$ 790,000
Major Foundations & Footings	$ 710,000
Instrumentation (Includes Instrument Air Package)	$ 920,000
Piping	$ 1,025,000
Electrical	$ 725,000
Other Installation Costs	
Fire Protection	$ 170,000
Painting	$ 17,000
TOTAL DIRECT INSTALLATION COSTS	$ 10,227,300

Source: Standard cost estimating procedures, vendor and contractor quotations (January, 1983), Butler Research and Engineering Company.

Note: Plant costs vary widely according to plant location, trade-offs in design, capital cost and plant operating costs, quality of materials, etc. This table is only an example to provide an "order of magnitude" estimate of project cost.

TABLE III-3

PROJECT COST SUMMARY
5 MM GALLON PER YEAR FUEL GRADE ETHANOL FACILITY

ITEM	(EXAMPLE ONLY)	COST
Direct Costs		
Site Development (Incl. Wastewater Treatment)		$ 640,000
Buildings		675,000
Installed Equipment (from previous page)		10,227,300
Sales Taxes (6% on 80% of site, buildings and equipment)		554,030
Total Direct Costs		$ 12,096,330
Indirect Costs		
Construction Plant		$ 200,100
Bonds & Insurance		105,000
Contractor's Fee		360,000
Total Indirect Costs		$ 665,100
Engineering, Construction Management, Start-up, etc.		$ 1,500,000
Process Warranty Insurance		$ 195,000
Land		$ 75,000
ESTIMATED TOTAL PROJECT COST (April, 1983)*		$ 14,531,430

*Does Not Include Construction Interest or Working Capital.

Source: Standard cost estimating procedures, vendor and contractor quotations (January, 1983), Butler Research and Engineering Company.

Note: Plant costs vary widely according to plant location, trade-offs in design, capital cost and plant operating costs, quality of materials, etc. This table is only an example to provide an "order of magnitude" estimate of project cost.

TABLE III-4

EQUIPMENT INSTALLATION COST SUMMARY
10 MM GALLON PER YEAR FUEL GRADE ETHANOL FACILITY
(Labor & Materials)

DESCRIPTION (EXAMPLE ONLY)	COST
Equipment	
Section 01 - Grain Storage & Handling	$ 659,645
Section 02 - Cooking Process	144,840
Section 03 - Hydrolysis	214,590
Section 04 - Fermentation	1,614,370
Section 05 & 06 - Binary Distillation and Dehydration	1,788,450
Section 07 - Liquid Solid Separation	763,970
Section 08 - Evaporation	807,995
Section 09 - Drying/Pelletizing	799,760
Section 10 - Denaturant/Ethanol Storage	224,000
Section 11 - DDGS Storage & Handling	190,700
Section 12 - Miscellaneous	587,900
Section 13 - Energy System	1,660,000
Total Equipment (Inc. Freight)	$ 9,456,220
Equipment Erection	$ 1,200,000
Major Foundations & Footings	$ 1,070,500
Instrumentation (Includes Instrument Air Package)	$ 1,315,000
Piping	$ 1,554,000
Electrical	$ 1,080,000
Other Installation Costs	
Fire Protection	$ 260,000
Painting	$ 25,000
TOTAL DIRECT INSTALLATION COSTS	$ 15,960,720

Source: Standard cost estimating procedures, vendor and contractor quotations (January, 1983), Butler Research and Engineering Company.

Note: Plant costs vary widely according to plant location, trade-offs in design, capital cost and plant operating costs, quality of materials, etc. This table is only an example to provide an "order of magnitude" estimate of project cost.

TABLE III-5

PROJECT COST SUMMARY
10 MM GALLON PER YEAR FUEL GRADE ETHANOL FACILITY

ITEM	COST
Direct Costs	
Site Development (Incl. Wastewater Treatment)	$ 990,000
Buildings	1,022,500
Installed Equipment (from previous page)	15,960,720
Sales Tax (6% on 80% of site, buildings, and equipment)	862,715
Total Direct Costs	$ 18,835,935
Indirect Costs	
Construction Plant	$ 316,650
Bonds & Insurance	183,500
Contractor's Fee	710,169
Total Indirect Costs	$ 1,210,319
Engineering, Construction Management, Start-up, etc.	$ 2,400,000
Process Warranty Insurance	$ 293,125
Land	$ 100,000
ESTIMATED TOTAL PROJECT COST (April, 1983)*	$ 22,839,379

*Does Not Include Construction Interest or Working Capital.

Source: Standard cost estimating procedures, vendor and contractor quotations (January, 1983), Butler Research and Engineering Company.

Note: Plant costs vary widely according to plant location, trade-offs in design, capital cost and plant operating costs, quality of materials, etc. This table is only an example to provide an "order of magnitude" estimate of project cost.

B. PROJECT FINANCING AND RETURNS

Table III-6 is a typical income statement and financial return calculation for two dry milling ethanol plants, of 5 and 10 million gallon per year capacity. Both plants include drying and solubles recovery equipment and coal fired boilers. Note that while both plants show comparable operating margins, the 10 million gallon/year plant is more profitable due to lower fixed costs per unit of production.

Both of the plants shown on Table III-6 assume a corn price of $2.35/bushel and an ethanol selling price of $1.70/gallon. DDGS price is assumed to be $150/ton for both plants. Both plants assume 20% equity financing with a 13% interest rate on the debt portion. The capital cost estimates include equipment, building, engineering, site development, land and interim interest costs. Capital costs utilized in the income and expense analysis were obtained from Tables III-3 and III-5. Working capital includes cash, receivables, inventory, raw materials, working progress and start-up costs.

It is important to look at financial projections in light of their sensitivity to changes in the base case assumptions. One of the chief concerns of potential investors in ethanol facilities is the sensitivity of returns to such variables as plant capital cost, raw material prices, and byproduct selling prices.

As Figure III-3 indicates, approximately 45-50% of the ultimate sale price of the ethanol is taken up by raw material costs (corn and chemicals). Thus, return on investment is most sensitive to corn prices. One reason dry milling may have an advantage over other processes is that the smaller size of dry milling plants should enable access to local cash grain markets, thus lower cost raw materials which are not as subject to commodity price fluctuations as larger regional plants. Dry milling plants also have the advantage of being easily convertible to other feedstocks (i.e. other grains or cellulose) which may be more economical in the future.

Return on total investment is also sensitive to plant capital cost and byproduct selling price. Clearly, both of these factors must be studied and weighed heavily before the decision to proceed with a plant is made.

TABLE III-6

INCOME & EXPENSE STATEMENT
FOR TYPICAL DRY MILLING ETHANOL PLANTS

ITEM	5 MM gal/yr. Plant	% of total Revenue	10 MM gal/yr. Plant	% of total Revenue
	(000's)		(000's)	
Revenue				
Alcohol	$ 8,500	74.1%	$17,000	74.1%
DDGS	2,828	24.6%	5,655	24.6%
Carbon dioxide	150	1.3%	300	1.3%
TOTAL REVENUE	$11,478	100.0%	$22,955	100.0%
Cost of Goods Sold				
Corn & chemicals	$ 5,344	46.6%	$10,688	46.6%
Direct labor	340	3.0%	596	2.6%
Utilities	1,300	11.3%	2,500	10.9%
Admin. & burden	530	4.6%	985	4.3%
TOTAL COST OF GOODS	$ 7,514	65.5%	$14,769	64.0%
NET OPERATING MARGIN	$ 3,964	34.5%	$ 8,186	36.0%
Fixed Expenses				
Interest	$ 850		$ 1,354	
Depreciation	1,468		2,226	
TOTAL FIXED EXPENSES	$ 2,318	20.0%	$ 3,580	15.5%
NET PRETAX INCOME	$ 1,646	14.3%	$ 4,606	20.1%
CAPITAL COST				
Plant & equipment	$14,531		$22,839	
Working capital, Construction interest, Escrow accounts, Financing fees	1,200		2,200	
TOTAL INVESTMENT	$15,731		$25,039	
APPROXIMATE AVERAGE RETURN ON TOTAL INVESTMENT				
Before taxes	10.5%		18.3%	

IV. STATE OF MINNESOTA PARTICIPATION

A. OTHER STATE'S PROGRAMS

In comparing the fifty states' initiatives on alcohol fuel as of January 1983, 32 states have some type of net state tax exemptions for ethanol/gasoline blends. The percentages of exemptions vary from state to state (see Table IV-1). Minnesota has legislation pending which will allow a 2¢ per gallon exemption as of July 1, 1983 and a 4¢ per gallon exemption as of July 1, 1985. This legislation is expected to be effective until 1992.

As of August 1980, nine states provided some type of sales tax forgiveness for ethanol/gasoline sales. The percentages varied from state to state. Minnesota currently has no such laws.

Nine states provide a state property tax deduction or exemption for ethanol plants. One state, Kentucky, allows a local property tax deduction. Minnesota currently provides no property tax deduction.

Four states provide income tax credits. Three states have income tax deductions and one state has an income tax reduction. North Carolina allows a 20% corporate and personal income tax credit. Minnesota Statutes 1978, Section 273.11, Subdivision 6, provided for a 20% income tax deduction on the first $10,000 spent by a producer of renewable energy (including ethanol, methane and methanol) for on-farm use only. However, this exemption expired December 31, 1982.

The following provides a comparison of states which are similar to Minnesota in crops, climate, geography and proximity.

Colorado

- 5¢ per gallon excise tax exemption, expires July 1, 1985.
- 98% property tax reduction which is temporary and has a decreasing scale rate.
- Alcohol must be produced in Colorado.

Illinois

- 3¢ per gallon decreasing excise tax exemption which will expire in 1986.

Indiana

- 5¢ per gallon excise tax exemption.
- Has an income tax deduction.

Iowa

- Has a decreasing excise tax exemption which will expire in 1987.

Kansas

- Has a decreasing excise tax exemption which will expire in 1985.
- The alcohol must be produced from grain products grown in Kansas.
- Production of alcohol must utilize 10 less energy units than would be contained in the converted motor vehicle fuel.

Kentucky

- Has a decreasing excise tax exemption which will expire in 1987.
- 99% state property tax reduction.
- 99% local property tax reduction.
- Alcohol plants must burn coal produced in Kentucky or convert to such use within 2 years of certificate receipt to qualify for the exemptions.

Nebraska

- 5¢ per gallon excise tax exemption.
- Alcohol must be produced in Nebraska.
- Beginning in 1982, the 5¢ excise tax exemption applies only to alcohol produced in a plant under construction or in operation by July 1, 1980.

North Dakota

- 4¢ per gallon excise tax exemption.
- 3% sales tax exemption which only applies when the gasohol is used for agricultural or industrial purposes.

Ohio

- 3.5¢ per gallon excise tax exemption.

Oklahoma

- 6.5¢ per gallon excise tax exemption which expires on October 1, 1984.

Oregon

- 100% income tax exemption.
- 50% investment tax credit, which has a decreasing scale rate and expires on January 1, 1985.
- 100% property tax reduction, which applies only to commercial plants and expires on October 3, 1985.

South Dakota

- 4¢ per gallon excise tax exemption which expires in June, 1983.
- 4% sales tax exemption which expires on June 30, 1985; legislation pending to extend exemption.
- 100% property tax credit which has a decreasing scale rate and has differing rates for small-scale and large-scale plants.
- 100% property tax credit which expires on July 1, 1986.

Wisconsin

- No excise tax exemption; bill currently pending.
- Allows alcohol fuel production systems to qualify for individual and corporate income tax credits.
- All State cars must run on fuel containing at least 10% ethanol.

There are four very common trends in state legislation:

1) Tax rates in most cases are decreasing with expiration dates in the mid to late 1980's.
2) Many states require that the alcohol be produced from products grown in that state.
3) Many states have alcohol promotion councils that promote the use of alcohol in the state or have a reciprocity clause with other states.
4) Most states have a program of testing alcohol fuels in state owned and operated vehicles.

TABLE IV-1

NET STATE TAX EXEMPTIONS FOR ETHANOL/GASOLINE BLENDS
IN THE UNITED STATES

(January 1983)
Expressed in cents per gallon

STATE	1982	83	84	85	86	87	88	89	90	91	92
Alabama	3	3	3	3	3	3	3	3	3	3	3
Alaska	8	8	8	8	8	8	8	8	8	8	8
Arizona	-	-	-	-	-	-	-	-	-	-	-
Arkansas*	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5/0	-
California	4	3	2	1	-	-	-	-	-	-	-
Colorado*+	5	5	5	5	-	-	-	-	-	-	-
Connecticut	1	1	1	1	1	1	1	1	1	1	1
Delaware	-	-	-	-	-	-	-	-	-	-	-
Florida	5	5/4	4	4/2	2	2/0	-	-	-	-	-
Georgia+	-	-	-	-	-	-	-	-	-	-	-
Hawaii*	4	4	4	4*	4*	4*	4*	4*	4*	4*	4*/0
Idaho*	4	4	4	4	4/0	-	-	-	-	-	-
Illinois+	3%	3/2%	2%	2/0	-	-	-	-	-	-	-
Indiana	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Iowa+	5	5/3	3/2	2/1	1/0	-	-	-	-	-	-
Kansas*+	2	2/1	1/0	-	-	-	-	-	-	-	-
Kentucky*	3.5	3.5	3.5	3.5	3.5/0	-	-	-	-	-	-
Louisiana*+	8	8	8	8	8	8	8	8/0	-	-	-

TABLE IV-1 (continued)

NET STATE TAX EXEMPTIONS FOR ETHANOL/GASOLINE BLENDS
IN THE UNITED STATES

(January 1983)
Expressed in cents per gallon

STATE	1982	83	84	85	86	87	88	89	90	91	92
Maine+	-	-	-	-	-	-	-	-	-	-	-
Maryland+	-	-	-	-	-	-	-	-	-	-	-
Massachusetts+	-	-	-	-	-	-	-	-	-	-	-
Michigan+*	5	5/4	4	2	1	-	-	-	-	-	-
Minnesota+	-	-	-	-	-	-	-	-	-	-	-
Mississippi+	-	-	-	-	-	-	-	-	-	-	-
Missouri+	-	-	-	-	-	-	-	-	-	-	-
Montana+	7	7	7	7/5	5	5/3	3	3	-	-	-
Nebraska+	5	5	5	5	5	5	5	5	5	5	5
Nevada	1	1	1	1	1	1	1	1	1	1	1
New Hampshire*+	5	5/0	-	-	-	-	-	-	-	-	
New Jersey	-	-	-	-	-	-	-	-	-	-	-
New Mexico*	10	10	10	10	10	10/0	-	-	-	-	-
New York+	-	-	-	-	-	-	-	-	-	-	-
North Carolina	2	2/1	1/0	-	-	-	-	-	-	-	-
North Dakota	4	4	4	4	4	4	4	4	4	4	4
Ohio	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Oklahoma+	6.5	6.5	6.5/0		-	-	-	-	-	-	-
Oregon	-	-	-	-	-	-	-	-	-	-	-
Pennsylvania+	-	-	-	-	-	-	-	-	-	-	-
Rhode Island	-	-	-	-	-	-	-	-	-	-	-

TABLE IV-1 (continued)

NET STATE TAX EXEMPTIONS FOR ETHANOL/GASOLINE BLENDS IN THE UNITED STATES

(January 1983)
Expressed in cents per gallon

STATE	1982	83	84	85	86	87	88	89	90	91	92
South Carolina+	7	-	-	-	-	-	-	-	-	-	-
South Dakota+	4	4/0	-	-	-	-	-	-	-	-	-
Tennessee*	-	4	4	4	4	4	4	-	-	-	-
Texas*	5	5	5	5	5/4	4/3	3/2	2/1	1	-	-
Utah*	5	5	5	5/0	-	-	-	-	-	-	-
Vermont	-	-	-	-	-	-	-	-	-	-	-
Virginia*+	8	8	8/6	6	6/4	4	4/2	2	2/0	0	0
Washington, DC	-	-	-	-	-	-	-	-	-	-	-
Washington State+	1.5	1.5	1.5	1.5	1.5	-	-	-	-	-	-
West Virginia	-	-	-	-	-	-	-	-	-	-	-
Wisconsin+	-	-	-	-	-	-	-	-	-	-	-
Wyoming	4	4	4/0	-	-	-	-	-	-	-	-

*Qualifications apply
+New Legislation Expected in 1983

Source: Information Resources Incorporated

B. DIFFICULTIES OF DEVELOPMENT IN MINNESOTA

There are many institutional barriers and disincentives to establishing new industries in Minnesota. Obviously, Minnesota's state government cannot support all of the key ingredients required for a successful business; good management judgement, aggressive marketing of products, inexpensive processing procedures, protection from changes in the market place and consumer preferences, etc. However, the Subcommittee has identified certain legislative and administrative difficulties to establishing ethanol and other agri-processing facilities within the State. The Subcommittee believes that overcoming these project development difficulties is as important as providing incentives.

The Subcommittee did not attempt to address issues of unemployment, income and excise taxes, or workman's compensation costs since it is expected that these issues will be addressed in other forums.

Lack of Ethanol Product Market Development Incentives

The federal government, to encourage the development of alternative energy production facilities, has established a marketing tax incentive for wholesalers/retailers who market ethanol blended fuels. Further, as noted in this Report, nearly every major agricultural state, except Minnesota, has an additional tax exemption. Minnesota has a population of four million people, uses approximately two billion gallons of gasoline a year, has a refinery production capacity of 1.2 billion gallons per year, yet sold only a very small amount of ethanol/gasoline blends in 1982. On the other hand, Iowa, which has a population of 2.9 million, and has no refinery production, sold 407 million gallons of ethanol blended fuel between January and October, 1982. THIS REPRESENTS APPROXIMATELY 30 PERCENT OF THE TOTAL MOTOR FUEL CONSUMED IN THE STATE OF IOWA. THE ABILITY OF THE ADDITIONAL STATE EXCISE TAX EXEMPTION TO STIMULATE ETHANOL MARKETING IS CLEARLY EVIDENT BY THIS COMPARISON.

Higher Capital Cost

Construction of a 5 to 10 million gallon per year fermentation ethanol plant typically involves a capital investment of between $2.00 and $3.00 per annual gallon of production. This amounts to a range of $10 million to $30 million per project. Minnesota is one of a small group of states which charges full sales tax on all major process equipment in a commercial facility. Coupled with higher employment taxes and sales tax on materials, construction costs are higher in Minnesota. THEREFORE, A PLANT BUILT IN MINNESOTA CAN EASILY COST 10% MORE THAN IN THE DAKOTAS OR IOWA. ON A $30 MILLION PROJECT, $3 MILLION IN ADDITIONAL COST DOES NOT GO UNNOTICED BY THE DEVELOPER.

Inflexible Environmental Regulation

STATE ENVIRONMENTAL REGULATIONS NOT ONLY EXCEED THE FEDERAL STANDARDS IN MOST CASES, BUT ALSO ARE REQUIRED TO BE MET PRIOR TO START OF PLANT CONSTRUCTION. THIS CAUSES ADDITIONAL COST, AND DELAYS PROJECT DEVELOPMENT. The Subcommittee is not asking for an across-the-board relaxation of environmental regulations for ethanol projects. The Subcommittee feels the State would be better served by regulations that are administered expeditiously and with some flexibility. MOST STATES HAVE AN EFFECTIVE INDUSTRIAL DEVELOPMENT AUTHORITY WHICH WORKS WITH THE ENVIRONMENTAL REGULATORY AUTHORITY TO BALANCE STATE ECONOMIC AND ENVIRONMENTAL GOALS.

Lack of Capital Availability

THERE IS A REAL LACK OF CAPITAL AVAILABILITY FOR PROJECT CONSTRUCTION IN MINNESOTA. FEWER THAN A DOZEN BANKS IN MINNESOTA HAVE LEGAL LENDING LIMITS ALLOWING THEM TO MAKE MORTGAGE LOANS LARGE ENOUGH TO QUALIFY FOR EVEN THE MANDATORY 5% PORTION OF A $20 MILLION FARMERS HOME ADMINISTRATION LOAN GUARANTEE. Furthermore, in the past, most State operated pension funds and insurance funds have invested in large facilities and companies outside of Minnesota, reducing available capital for home grown businesses. Finally, construction loans for facilities costing $10 to $30 million can be organized by smaller banks, although only a few banks within the State have legal lending limits high enough to make these loans. Thus, the State needs to examine what it can do to encourage capital to remain invested in Minnesota and attract capital from outside the State to construct these facilities.

Lack of Coordinated State Agency Permit Processes

MINNESOTA'S ADMINISTRATIVE SERVICES DO NOT COMPARE FAVORABLY WITH THOSE OF OTHER STATES. Since ethanol is a new industry with little environmental impact history, the discretionary authority of these agencies can either be very supportive or very discouraging. MOST STATES ARE WILLING TO WEIGH A LARGE VOLUME OF EVIDENCE, STUDY, AND HISTORY OF SIMILAR FACILITIES AND REACT TO A "MOST-LIKELY-TO-OCCUR" SCENERIO. MINNESOTA'S POSITION HAS BEEN ONE OF TAKING THE "WORST-POSSIBLE-OF-ALL-CASES" APPROACH. While permitting officials from other states encourage ethanol project development by offering various types of assistance, including temporary construction permits, Minnesota agency personel have been found to be less helpful. This causes three main difficulties; 1) uncertainty as to whether the permit will be approved (and final conditions of the approval); 2) delays in responses for approval, which increase project costs; and 3) confusion, caused by a lack of coordination among the regulators who often require plants to meet specifications which are contradictory to manufacturers' recommendations or rules from other agencies.

As is the case with other industrial development and agri-processing projects, a number of permits are typically required prior to construction of an ethanol plant. These permits generally include air quality, water quality, building and water appropriations permits, zoning and land use approvals. A total of 33 different permits with 21 different state and federal agencies are required for ethanol plants in Minnesota. Anything less than the most cooperative and supportive agencies results in extreme difficulty in completing the permitting process. A case study follows:

Case Study

In order to demonstrate the impacts of existing State agency barriers to the development of agricultural processing facilities in Minnesota, a case study has been prepared to describe the experience of a Minnesota developer. Agri-Energy, Inc., a Minnesota corporation, is planning an ethanol plant in Crookston, Minnesota, and wishes to build other plants in the Red River Valley area. The engineering and development work on the Minnesota plant coincided with a similar ethanol project in Kansas. A comparison of the level of cooperation provided to these projects by the two states, as experienced by the Minnesota based project engineer, is provided below:

Well Water Permit

Kansas: Orderly procedure of application, administrative review, and permit award.

Total time required - 1 month.

Minnesota: Cumbersome and costly process of application.

Numerous meetings with agency personnel.

Requirements of aquifer testing, reports, additional information, etc.

Total time required for 150 gpm well permit on under-utilized aquifer - 6 months.

Total cost of testing, reports, etc. - $5,000.

Wastewater Permit

Kansas: Orderly process of application, design, administrative review, revision, public notice and permit award.

General cooperation from agency.

Total time required - 3 months.

Minnesota: Agency ignored sophisticated lab analysis conducted to substantiate design of wastewater facility.

Required overdesign of wastewater facilities based on State sewage sludge standards.

Cost developer extra $20,000 for lab analysis and $90,000 for overdesign.

Permit still pending after 1 year.

Air Quality Permit

Kansas: Orderly permit application, review and permit process.

Total time required--2 months.

Minnesota: Refused to accept boiler manufacturer's air quality performance guarantees.

Total time required - 6 months.

General State Support

Kansas: Governor Carlin, Senator Dole and more than 30 local and State officials at groundbreaking ceremony.

Helpful advice and support such as contacting federal agencies for clearances, temporary review waivers, and federal loan guarantee support.

Minnesota: No representatives from Energy Division of DEPD or former Governor's office at groundbreaking ceremony (although several local Minnesota legislators and more than 5 North Dakota state officials were present).

Minnesota DEPD - Energy Division official (untrained in investment counseling) advised potential investors that ethanol industry is "not a good investment."

No tax credits, higher workmen's compensation rates, no sales tax exemption.

After the experience with the first plant in Minnesota, the developer selected four new sites for subsequent plants, three of which were in North Dakota.

The Energy Division of the Minnesota Department of Energy, Planning and Development (DEPD) required that another Minnesota developer (not Agri-Energy) undergo a "Certificate of Need" hearing process for its proposed ethanol plant, as is required of large electrical generation facilities. Certificates of Need are not known to be required for ethanol plants in any other state. This process cost the developer over $20,000.

These are just a few examples of events that have occured between certain Minnesota agencies and ethanol project developers which have made the industry feel less than welcome in Minnesota.

V. RECOMMENDATIONS

It is clear to the Subcommittee that the State must focus its initiatives in two areas to capture the ethanol opportunities in particular, and the agri-processing opportunities in general. First, the State must develop a general multi-program approach to encourage industry retention, expansion and recruitment in Minnesota. Second, Minnesota must develop a specific incentive program for the ethanol industry to match the programs offered by surrounding states.

A. GENERAL INDUSTRIAL DEVELOPMENT SUPPORT

AGRI-PROCESSING IS PARTICULARLY HARD HIT BY THE LACK OF COMPREHENSIVE STATE INDUSTRIAL SUPPORT LEGISLATION. In Minnesota, industrial development is largely left to the major Metropolitan areas. In fact, Minneapolis, St. Paul, Duluth, Mankato, and Rochester have exceptionally good industrial recruitment programs. However, these urban sponsored programs do little for industrial development in the rural area. Industrial development in rural areas primarily means agri-processing. THEREFORE, THE LACK OF A STATEWIDE INDUSTRIAL DEVELOPMENT PROGRAM ARMED WITH THE LEGISLATIVE AUTHORITY TO GRANT SPECIAL INCENTIVES FOR SPECIFIC INDUSTRIAL PROJECTS HAS HAD A SEVERE IMPACT ON AGRI-PROCESSING FACILITIES.

Historically, the State Department of Economic Development, now part of the Department of Energy, Planning and Development, has focused on tourism, planning and administering federal development programs. An enhanced Department of Energy, Planning and Development focusing on industrial development would be extremely useful to the ethanol industry. The attention of a Statewide industrial development authority to the difficulties of industrial development discussed in this Report would be an important step in recruiting the ethanol industry to Minnesota.

B. SPECIAL INCENTIVES FOR ETHANOL PRODUCTION

The ethanol industry incentives recommended by the Subcommittee fall into two categories; 1) Legislative recommendations, and 2) Administrative recommendations.

Legislative Recommendations

The Subcommittee recommends that the Minnesota Legislature pass legislation to support the following four needs of the ethanol industry: 1) provide excise tax exemption for ethanol/gasoline blends, 2) establish a loan guarantee program for plants built in the State, 3) establish a permit expediting authority (or Ombudsman) to support firms planning new facilities in the State, and 4) provide sales tax forgiveness for major process equipment installed in the ethanol plant.

Excise Tax Exemption

The Subcommittee recommends the State provide a 4¢ per gallon State excise tax exemption on unleaded gasoline blended in a 9 to 1 ratio with ethanol. The legislation should be patterned after the federal exemption and should be legislatively mandated to remain in effect until 1992. The excise tax exemption should be phased into effect with a 2¢ per gallon exemption starting as soon as possible and an additional 2¢ exemption effective two years later. This phased approach is intended to avoid "flooding" of the Minnesota ethanol market with product produced outside of Minnesota. THE 4¢ EXEMPTION WILL PROVIDE THE STIMULUS FOR A MARKET DISTRIBUTION SYSTEM AND INFRASTRUCTURE REQUIRED FOR A STATEWIDE INDUSTRY.

Initially this will benefit ethanol producers outside the State. However, the Subcommittee believes that the 5¢ to 10¢ per gallon local transportation cost advantage to producers within the State will quickly create sufficient incentives for ethanol production in Minnesota. This will be particularly true when the tax exemption is combined with a State loan guarantee program. The partial excise tax exemption would be comparable to the support of surrounding states.

The four cent per gallon gasoline excise tax exemption is the key to marketing ethanol in Minnesota. As the marketing section of this Report indicates, a ten cent per gallon support for gasoline blended with ethanol will make ethanol competitive with any other octane enhancer in the short-run. In the long-run ethanol will be cost effective on its own. Therefore, the Subcommittee supports the 1992 sunset provision. The State's five cents per gallon exemption, plus the federal government's five cent per gallon exemption will provide the necessary 10¢ support. THE TAX EXEMPTION WOULD HAVE NO EFFECT ON THE STATE'S GENERAL FUND SINCE ALL HIGHWAY TAX REVENUES ARE DEDICATED TO THE HIGHWAY USER DISTRIBUTION FUND.

In defining ethanol for this legislation, the law must be careful not to specify ethanol as "anhydrous" or 198 to 200 "proof." These terms are often used, but are not legally correct. A special fuel grade ethanol should be defined according to the proposed new ASTM standards for fuel grade ethanol. The standard for fuel grade ethanol should be summarized as follows: "Agriculturally derived fermentation ethyl alcohol containing not more than 1.25 percent water by weight at point of blending with gasoline, nor more than two percent (2%) by weight heads and fusel oils normally derived during fermentation, nor more than the U.S. Bureau of Alcohol, Tobacco and Firearms required amount of denaturant compatable for use in blending with unleaded gasoline. Water content shall be determined by method E203 test for water using Karl Fisher Reagent as published in The Annual Book of ASTM Standards Part 30.

Loan Guarantee Program

The Subcommittee recommends the establishment of a loan guarantee program to provide a one time capital formation stimulus to encourage development of the first generation of ethanol plants to be located in Minnesota. The loan guarantee program will work in conjunction with the excise tax exemption to support new plants in the State.

OVER $130 MILLION OF NEW PLANT CONSTRUCTION COULD BE GENERATED BY LESS THAN A $20 MILLION RESERVE FUND (WHICH COULD BE RETURNED TO THE STATE) USING A LOAN GUARANTEE PROGRAM. This can be demonstrated by the following program funding description. Of the $130 million in project construction, 20% or $26 million would be provided by investors in the form of equity. The remaining 80%, or $104 million, would be financed as debt. The State could provide loan guarantees for 95% of the debt portion or $98.8 million. Sponsoring banks should be required to be at risk for the unguaranteed portion of the loan. Since the equity and capital purchased under the loan would substantially collateralize the loan guarantee, the State would need to maintain a reserve fund for the guaranteed portion of the loans of only $19.76 million (a 5 to 1 leverage). Unless there were major loan defaults, the reserve fund would be repaid by the projects and could be retired on a pro-rata basis with the retirement of the loans. THROUGHOUT THE LIFE OF THE PROGRAM THE RESERVE FUND WOULD BE SHOWN AS AN ASSET ON THE STATE'S ACCOUNTS, RATHER THAN AN EXPENDITURE. THIS EXPLAINS THE POPULARITY OF LOAN GUARANTEE PROGRAMS WITH THE FEDERAL GOVERNMENT. This will enable the construction of 40 to 50 million gallons per year of ethanol production capacity. A loan guarantee fee and a grain check-off of 1¢ per bushel to be collected by the ethanol plant should be used to cover administrative costs of the program.

Permit Expediting Authority

Establish Permit Ombudsman office in Governor's office with broad authority to expedite permit issues. For example, the legislature could establish mandatory review periods which fix the period during which a permit application review must be completed. The intent of this office is not to provide ethanol projects special exemptions from the environmental requirements of similar projects. The intent of this office is to accelerate the review process and ameliorate many of the bureaucratic barriers facing developers.

Sales Tax Forgiveness

The Subcommittee recommends a limited sales tax exemption for main process equipment permanently installed in an ethanol plant. This would be similar to the current exemption on real estate. Sales tax would continue to be paid on construction materials and consumables used by the plant. THE SUBCOMMITTEE DOES NOT RECOMMEND PROPERTY TAX FORGIVENESS, SPECIAL ENERGY INVESTMENT CREDITS, ETC. The Subcommittee understands that under limited circumstances, potential property tax breaks are already available under M.S. 273.86 and M.S. 273.1313 and M.S. 273.13, Subdivision 9, clause 4. Various bills have been introduced in the legislature in previous years to provide sales tax breaks for new or expanding industry, which often do not even receive committee hearings. In spite of this history, the Subcommittee recommends a partial sales tax forgiveness on main process equipment for ethanol plants as an effective means of encouraging development of the industry in Minnesota. It should be noted that a portion of this State forgiveness would be offset by other taxes to be paid by the new plant.

Administrative Recommendations

The Subcommittee has the following recommendations regarding the administration of the loan guarantee program and eligibility requirements for projects:

1) A special project review and program oversight committee comprised of knowledgeable individuals should be established by the Governor. The membership might be as follows:

   a) Member of Governor's staff
   b) Commissioner of Agriculture
   c) Representative of Agri-business
   d) Representative of Technical Fields
   e) Representative of Construction Industry
   f) Representative of Chemical/Energy Industry
   g) Representative from Agriculture
   h) Representative from Banking Industry

   Duties would be to review and approve policies established by program administrator and to review and approve projects.

2) Program should be administered through the State Department of Agriculture or directly through the Governor's office with a full-time administrator. The cost of funding the administration of the program can be handled by a loan fee to be charged for each loan guarantee awarded and the grain check-off fee for each bushel processed into ethanol.

3) A simple eligibility criteria document should be published with the program announcement. All applications should be due on a specified date and reviewed simultaneously. Committee can select from the best of the projects.

4) Overview of Application processing is as follows:

   a) Interested project sponsor obtains eligibility document and application and determines if proposed project meets criteria.
   b) Project Sponsor completes application and submits to program administrator.
   c) Program administrator has a fixed amount of time to verify completeness, accuracy and eligibility, and forwards application to Review Committee.
   d) Review Committee approves project and issues a Conditional Commitment. Commitment should be conditional on securing necessary loans, equity and permits.
   e) Review Committee issues final approval.
   f) Construction begins.

5) Loan guarantee to cover both construction and permanent loan and be effective from first construction drawdown to retirement of permanent mortgage.

6) Loan guarantee to be merchantable in the secondary financial market (similar to a Fanny Mae)

7) Owner equity should be 20% of project capitalization, 80% should be debt. Project capitalization shall include plant and equipment, engineering, construction, insurance and bonds, construction interest, real estate, working capital, legal and accounting, equity syndication and other project development costs amortizable as a capital expense under IRS regulations.

8) Loan guarantee program should guarantee 95% of the 80% debt portion of project capitalization. The sponsoring bank should be required to have some exposure. This is extremely important to maintaining project discipline.

9) "At risk" equity portion of the project cost should be drawn down pro rata with the construction loan funds.

The Subcommittee also makes the following recommendations relating to project eligibility for loan guarantee:

1) Marketing - Developer should have market commitment, at least in the form of a firm letter of intent, from a bona fide purchaser/user of plant products for at least 50% of anticipated production. A market plan should be presented for the remaining portion.

2) Project Size - The program should be targeted to plants in the 5 to 10 million gallon per year size. Smaller or larger plants are not precluded, but should be discouraged under the loan guarantee program. The smaller plant developers must demonstrate some clear cost advantages which insure the profitability of the project. Under comparable circumstances the profitability of plants under 5 million gallons per year can become questionable. Larger projects are not precluded, but would require a disproportionate share of the funds available. The Subcommittee recommends spreading the available funds and risk among several projects.

3) Technology - Eligible plants should use grain dry milling and produce anhydrous ethanol using conventional yeast, batch fermentation, molecular sieves or azeotrope ethanol dehydrators. Allowable plant feedstock (raw material) should only be those usable by commercially proven conventional fermentation technologies. This should include use of feedstocks such as corn, wheat and barley. Feedstocks requiring the exclusive use of commercially unproven technologies such as wood chips, cattails, municipal waste, Jerusalem artichokes, potatoes, or sugarbeets should be ineligible for the loan guarantee. Multiple feedstock projects (i.e. combinations of the above) should be considered as long as the primary feedstock is grain.

4) Energy Systems - Priority should be given to projects that utilize fuels other than natural gas or petroleum. The Subcommittee encourages alternative fuel systems, such as wood or agricultural residues, cogeneration, or solid fuel such as coal. However, conventional fueled plants will not be ineligible if plant economics so dictate.

5) Construction - Plants in the recommended size range should be designed and constructed according to specifications developed specifically for the plant. Packaged pre-engineered, pre-constructed plants in the over 5 million gallon per year size have not proven themselves technically feasible. In addition to new construction, plant retrofits, expansions and conversions should be eligible for loan guarantee awards.

6) Project Costs - Project capital costs should fall within the range indicated in Figure III-2. Projected Income and Expenses for the proposed projects should approximate those shown in Figure III-6.

7) Equipment - Virtually all of the equipment selected to meet the requirements of the State loan guarantee program should be selected from existing industrial applications. Nearly every piece of equipment should be supplied "off-the-shelf" by long established and reputable manufacturers with operating histories in other industries. Equipment should be supplied complete with full manufacturer's warranties, parts inventories, service and maintenance support. The use of plant equipment manufactured in Minnesota should be encouraged, whenever possible.

8) Contractor - The project should have a prime contractor for all construction functions capable of being bonded for both performance and payment for the entire project. Contractor insurance coverage must include property coverage for fire, vandalism, etc., worker's compensation insurance, liability insurance for general liability to cover bodily injury and property damage. Contractor should have industrial process experience of at least one project within the past 5 years of a similar type and of at least 50% of size in terms of dollar volume of contract. Contractor should provide a 1 year warranty on workmanship. Contractor must build under a firm fixed price lump sum contract. Cost plus or flexible pricing is not appropriate for ethanol projects with loan guarantees. Projects utilizing Minnesota contractors and labor should be given priority over projects specifying non-Minnesota contractors. However, projects utilizing non-Minnesota contractors shall not be ineligible for loan guarantee awards.

9) Engineer - Must be able to assign to the project at least one Registered Professional in Minnesota for each of the Chemical, Mechanical, Electrical, Civil and Structural Engineering disciplines. A construction field engineer must be stationed on the site. Projects utilizing Minnesota engineers should be given priority over projects specifying non-Minnesota engineers. However, projects utilizing non-Minnesota engineers shall not be ineligible for loan guarantee awards. Engineer must be able to provide Errors & Omissions Insurance of at least a $1 million limit and Process Design and Plant Performance Warranty Insurance of at least a $5 million limit. Process Warranty Insurance shall guarantee the plant to perform at a minimum as follows:

   a) 2.4 gallons per bushel of corn (2.2 gallons per bushel of barley)
   b) 330 days per year of 24 hour per day operation
   c) Quantity of DDGS
   d) Quality of ethanol and DDGS, (i.e. ethanol at 1% moisture and DDGS at 10% moisture)

10) Safety & Codes - All construction design should be required to meet or surpass standards of the Minnesota State Building Code for General Construction. All appropriate ASTM, ACI, AISC and UBC standards must also be met. All roadways, foundations, fire protection devices, plumbing, electrical and piping installation must meet building code and industry standards. The process design, equipment, buildings and facilities specified to be utilized in the applicant plant should be reviewed by a major industrial insurance underwriter. The following are several safety features which should be included in the plant design:

   a) Explosion-proof electrical system
   b) Safety shut-off switches
   c) OSHA approved guards, ladders, walkways, etc.
   d) Foam fire protection system

APPENDIX A - INDUSTRY ISSUES

The increasing interest in developing ethanol into a major alternative energy and chemical source raises a series of important questions. In this Appendix, various issues are presented in an effort to fairly represent the current status of ethanol production. General issues such as food vs. fuel, need for government support, energy production or efficiency, status of the technology, plant cost, byproduct price and commodity prices are discussed.

FOOD VS. FUEL

One question often asked is; will the production of alcohol from farm commodities force a choice between food or fuel? In reality, the plants are designed to produce both food and fuel and do not force such a choice.

Only the starch (carbohydrate) is removed when grains are processed to produce ethanol. Nearly all the protein, vitamins and minerals in the original grain are recovered in the byproduct (DDGS). In fact, the yeast actually adds protein to the byproduct. This byproduct is equal in weight to about one-third of the original grain but has concentrated the protein from 6% - 9% to 27% - 30% protein.

In the 1981-1982 crop year, 6.95 billion bushels of U.S. corn were consumed. Of this amount, 4.17 billion bushels were fed to livestock, 1.96 billion bushels were exported (primarily for use as livestock feed), and 811 million bushels (or about 11% of the total) was used for food, alcohol and seed purposes. Much of that used for food went into the production of corn fructose (a sugar substitute) in wet milling plants. Approximately 6.13 billion bushels, 88% of the total, was fed to livestock in the U.S. or overseas. Current surpluses of corn are at record levels with supply in excess of demand to the point that a large quantity of corn is spoiling, and USDA has provided some of this corn to ethanol plants at attractive prices for immediate processing. The U.S. Department of Agriculture has also proposed a program called PIK to try to reduce this over supply.

Studies recognize the superior quality of the high protein byproduct (DDGS) as a livestock feed. The protein in the byproduct has a high "by-pass" value, which allows feed ingested by the animal to be converted to meat in a highly efficient manner. DDGS protein is used more effectively than when corn is fed directly. This allows much of the corn in the ration to be replaced by roughage, such as corn silage.

These tests clearly indicate that the starch from the corn can be removed for conversion into ethanol with little or no impact on red meat production. The meat produced from the feeding of protein byproduct and crop residue would be of the leaner variety that is increasingly in demand by consumers today.

NEED FOR GOVERNMENT SUPPORT

Regardless of the potential profitability of an industry such as ethanol, it would continue to be difficult to obtain capital financing for first generation projects. Lack of investor understanding of the dimensions of the multi-faceted aspects of this industry has been a major impediment to capital acquisition in the ethanol industry. Over the recent history of severe capital scarcity in all industries, investors have focused on industries they know and understand. Also, venture capital is very rarely available for large industrial processing facilities, and is usually reserved for high technology product development. Historically, U.S. capital markets have left capital financing for major industrial projects to the companies within that industry.

However, ethanol does not fit into the main line of business of any existing industry. It has the components of both the chemical/energy and the agri-processing industries. Whereas the chemical/energy processing industry is very confident in their ability to produce and market ethanol, they have not had a basis for understanding commodity markets and price fluctuations. They also have had little experience with marketing the significant byproduct, DDGS. In the case of the agri-processing industry, which has a wide variety of experience dealing with the fluctuations of commodity pricing and marketing of DDGS, they have little experience with marketing ethanol.

As a result, ethanol production became an industry caught between chemical/energy production industries and agri-processing industries. Without one of these industries to champion projects and produce capital for industrial expansion, it has been inordinately difficult to finance the first generation of projects. This, of course, has created a significant opportunity to form an entirely new industry, one that bridges both agri-processing and the chemical/energy industries. This is the reason that several grass-roots developers are successfully operating in the ethanol industry. Also, most of the major projects operating today are joint ventures of agri-processing and chemical/energy companies.

Therefore, the government support programs, particularly the loan guarantee programs, which provide capital financing, are necessary only to build the first generation of projects. After the new businesses and the first generation of plants have proven themselves, it is the general concensus within the industry that government support for capital formation will no longer be necessary. The question, "Why should Minnesota develop subsidy and support programs?" is also a fair question. The federal programs obviously have been successful in stimulating a large amount of growth in this industry as discussed earlier in this Report. The need for a Minnesota program is to insure that this growth will take place in Minnesota, rather than surrounding states.

PLANT ENERGY EFFICIENCIES

In the early days of the fuel alcohol programs, many detractors claimed that production of fuel alcohol from biomass was not energy efficient because it "used more energy than it produced". This issue arose when initial research indicated large energy consumption in beverage alcohol plants built in the early to mid 1900's. Although the media tends to cling to this issue, it is almost universally considered invalid under current production strategies and technology. Following excerpts from a report by the Energy Systems Division of TRW, Inc. prepared for the DOE summarize this issue:

- "By necessity, any energy conversion process - for example, generation of electricity from coal or refining of gasoline from crude petroleum - reduces the total energy that is eventually available to consumers. This phenomenon is commonly accepted in transforming a less desirable form of energy to a more desirable form. Thus, a coal-fired power plant that is only 33 percent efficient is considered acceptable because it transforms coal to a more useful form of energy, electricity.

- "The essential question that must be asked is, 'Does the production of ethanol achieve a net gain in a more desirable form of energy?' Put more simply, can the production of ethanol and its use as a motor fuel or chemical feedstock reduce the need for imported petroleum in this country? Or does the production of ethanol create a premium form of energy which is more useful to consumers than grains?

- "In this study the investment of energy (in the form of premium fuels) in alcohol production includes all investments from cultivating, harvesting or gathering the feedstock and raw materials, through conversion of the feedstock to alcohol, to the delivery to the end-user.

- "Total net energy gain defined to include all energy inputs (low-grade fuels and premium fuels) does not focus attention on the advantages that biomass alcohol processes offer in using low-utility fuels (such as coal and solar energy) to produce premium transportation fuel.

- "For all the specific processes and options considered, ethanol can be produced from biomass with net gains in premium fuels. This conclusion holds even when the ethanol production processes are treated as being premium fuel (petroleum or natural gas) intensive, if the plant utilizes the innovative, energy-efficient designs which are currently available."

STATUS OF THE TECHNOLOGY

There are two important aspects of plant technology for small and medium size plants which are of considerable interest; 1) Fuel alcohol as a proven technology and 2) Resistance of plant equipment to premature obsolescence.

Ethanol as a Proven Technology

Ethanol produced from grain represents the most commercially viable technology currently available for the production of alternative liquid fuels and chemicals. A well engineered ethanol plant is a balance of conventional technology to insure plant reliability and design innovation to insure long term competitiveness of the production facility. Nearly every piece of equipment specified in the plant will be supplied by one or more long established and reputable manufacturers. This equipment is widely used in other industries and therefore has an established market and resale value. Each piece of equipment can be supplied complete with warranties, parts, service and maintenance support. Most companies are fortifying this conventional technology by utilizing highly specialized knowledge in new control systems, energy efficient equipment, modern microbiology and biochemistry, and advanced process technology to insure maximum plant efficiency. Reputable engineering and contracting firms can offer complete surety bonds which guarantee plant performance.

Resistance of Plant to Premature Obsolescence

A well designed ethanol plant can benefit from the advantages of the use of conventional technology without being susceptible to premature obsolescence. The conversion of grain to ethanol involves many individual process steps. The equipment required for each process step does not represent more than 15% of the total project cost depending on plant size. Therefore, if a substantially new development were to become commercially available for a particular process step, plant management could afford to acquire this technology without major capital reinvestment.

Similarly, the cost of production represented by each process step (excluding grain) is less than 11% of the total cost of production (depending on plant size and process technologies). The net effect on the total cost per unit of production for the entire operation would be negligible even if a major breakthrough were to substantially reduce the cost of a particular process.

This inherent protection from obsolescence and relative flexibility for plant modification is important when considering the alternative products and feedstocks that the plant may be required to process in the future. The significant breakthrough anticipated in ethanol production technology pertains to microbiological developments that could be readily applied to plants currently being planned and built.

PLANT COST

This variable refers to the capital cost of facilities and equipment which is particularly critical with current high interest rates. Plant capital costs (not production costs) currently range from $1.50 to $3.50 per annual gallon of production. This relatively wide range results from the variability of technical approaches and the many options for byproduct production. Most plants typically cost in the area of $2.50 per annual gallon of production. It is widely recognized that overall plant economics plant are impaired above the $3.00 level unless the additional capital results in substantial operating cost saving or substantial added value in products.

BYPRODUCT PRICE

Byproduct price refers to the price per ton of DDGS. Although this is not a true operating cost when considering the costs of ethanol production, the revenue from byproduct sales may be credited against the cost of production of ethanol. The relationship of byproduct price to grain price is an important aspect of plant economics. As discussed in the following commodities risk section, byproduct price tends to increase with grain prices. Therefore, the sensitivity of byproduct prices often works in favor of plant economics.

GRAIN PRICES AND COMMODITY RISK

Ethanol production facilities are faced with price uncertainty for inputs as well as finished products. The specific risks center around the cost of agricultural commodities used as a feedstock for production. Grain, which is the primary feedstock for ethanol plants, may comprise up to 40% of the cost of the final product. Therefore, operating costs and product prices will be directly linked to the variable price levels commonly found in agricultural markets. However, these risks are reduced by several influencing market characteristics.

While the Chicago cash market price for corn peaked at $3.98 per bushel in early 1981, this price includes transportation costs and does not indicate the prices paid to farmers at most proposed plant sites. Farmers were paid approximately $3.00 per bushel for their corn in May, 1982, with an annual average of $2.50 per bushel for 1980. This difference between local and Chicago Board prices reflects transportation expenses and is often referred to as the "Basis". The Basis at various Minnesota locations has been as high as $.80 per bushel due to increasing transportation costs. The current price for corn on the Chicago board is $2.69 per bushel (February 28, 1983).

The best hedging mechanism is to sell the ethanol and the DDGS at the same time the corn is purchased. However, if product sales cannot be made immediately, the corn may be hedged on the Chicago Board of Trade. Minnsota corn generally sells at a discount to Iowa and Illinois corn, due to greater distances from the major markets. Given increased demand by Minnesota-based plants, the discount for Minnesota corn will be substantially narrowed. This will benefit the Minnesota farmer, while not appreciably diminishing the plant's economics.

Increases in the price of grain will have a much smaller effect on overall profit than would generally be expected, since a portion of end product prices rise along with the price of inputs. As grain prices rise, the market prices for DDGS have historically followed these increases. Based on historical trends, DDGS price increases could be expected to offset 40 to 60% of the increased costs experienced due to grain price increases.

Based solely on the profit margins of plants currently planned, it is estimated corn could rise to $4.00 per bushel before the plant would begin to lose money at current revenues and costs. Considering the history of DDGS revenue offset, corn could actually rise 50% higher or $6.00 per bushel. These figures are considerably higher than the highest historical price paid for corn. These relationships hold true for all grains.

Measures similar to those used by farmers and grain merchants can be employed to reduce the risks caused by price instability. Hedging in the futures market for grain and grain products can reduce the overall impact of markets fluctuations on these facilities. If the proper measures are taken, set prices for inputs and associated profit margins can be "locked-in". Although there are transaction costs associated with hedging, this type of price insurance is sometimes extremely valuable. A careful review of commodities price and plant economics demonstrates that properly designed and managed ethanol plants are not as sensitive to input and product price fluctuation as they may appear upon first inspection.

PLANT SIZE AND LOCATIONS

The basic ethanol production technology can be applied to three groups of plant sizes which have been adopted by the industry:

- <u>Farm (small) scale plants</u>. These plants typically use a dry milling process to produce between 5,000 and 2 million gallons per year of hydrous (160 proof to 190 proof) ethanol primarily for direct fuel use in farm equipment. Wet protein feed is produced and fed to farm livestock.

- <u>Community (medium) sized plants</u>. These plants typically use a dry milling process to produce between 2 and 20 million gallons of anhydrous (198+ proof) ethanol for use as direct fuel, a fuel additive or octane booster, or as an industrial chemical. Dry high protein feed as Distillers Dried Grain and Solubles (DDGS) is produced and sold as a livestock feed supplement locally, nationally or internationally. Human consumable protein can also be produced for sale to national or international markets.

- <u>Regional (large) scale grain processing plants</u>. These plants typically use wet milling to recover more products from grain such as fructose (corn sugar), corn oil, corn syrup, germ, gluten as well as producing 20 to 100 million gallons per year of anhydrous ethanol.

A comprehensive analysis of raw materials (feedstocks) production systems, product markets, technology of production and transportation economics of both inputs and end products should be considered when making a determination of plant size and location. However, this type of decision is primarily determined by the relationship of economies of scale in the production process and the economics of transportion of raw materials and finished goods.

The major transportation cost in ethanol production is the cost of shipping raw material feedstocks. Feedstock costs increase dramatically as the distance over which these inputs must be transported grows. Thus, the issue becomes whether to locate the plant near its source of feedstocks and transport the finished products to market or vice versa. Locating the plants at the feedstock source will lower transportation costs if the feedstocks have a higher bulk than the finished product. Since feedstocks have a bulk substantially higher than ethanol, locating plants at the source of the feedstock will greatly reduce transportation cost. Also, the feedstocks for ethanol production are dispersed over a wide geographic area. A dispersed feedstock source will increase the magnitude of the effects of transportation costs. The inherent high transportation costs of feedstock of ethanol plants and their rapid escalation as plant size increases suggest careful consideration of the size and locational relationships in ethanol production is required.

The major offsetting factor in considering transportation cost is economies of scale in production. Economies of scale refer to the concept of increased efficiency and reduced cost of operations per unit of production as a plant increases in size. However, the larger the plant, the greater the volume of material and product that must be transported to and from the plant site. Therefore, it is the optimal balance of transportation cost and economies of scale which determine the most desirable plant size and location.

Detailed capital and operating cost analyses have been conducted on plants ranging from 100,000 gpy to 25 mmgpy using a dry milling process and from 20 mmgpy to 50 mmgpy using a wet milling process. The results of these analyses have shown that there are substantial economies of scale from 100,000 gpy to 5 mmgpy with conventional technology. As a result, the costs per unit of production rise dramatically as plant size is reduced below 5 mmgpy. (However, research has shown that smaller plants could obtain scale economies by the development of a fully integrated, microprocessor controlled small scale production technology.) The analysis revealed smaller economies of scale in dry milling plants between 5 and 20 mmgpy in size as a result of enlarging plants from 5 to 20 mmgpy. Finally, substantial economies of scale were identified in all wet milling plant sizes, particularly in the 20 mmgpy to 50 mmgpy range.

The conceptual trade-off between feedstock transportation costs and economies of scale in production can be demonstrated in the developing structure of the industry. For example, a 20 mmgpy dry milling plant will be somewhat more efficient in terms of cost of production than a 5 mmgpy plant. However, the 20 mmgpy plant in most cases will be forced to purchase a majority of its grain in the regional commodities market. As discussed in the section on Commodities Risk, the regional market price for feedstocks may be considerably higher. Since feedstock costs represent 40% of the total costs of production, some of the efficiencies of the larger plant size are offset by the increased feedstock cost. The 5 mmgpy plant can purchase all grain locally to partially offset the loss of efficiency from the small plant size. A wet milling process, or other method of significantly enhancing the value of products, is required to offset the inherent transportation cost disadvantage of larger plants

Three business segments emerge as a result of the analyses. The first includes the large regional wet milling grain processing plant which produces a multitude of end products. This plant would be in excess of 20 mmgpy in production and require a very large capital investment. However, these plants have sufficient value added due to the many products resulting from the wet milling process to offset the feedstock price disadvantage resulting from transportation costs. The second segment is the community based plant which produces only ethanol and DDGS. This plant would be in the 2 to 20 mmgpy size range. These plants have the majority of the advantages of scale economies and can buy feedstock at substantially reduced prices by buying feedstocks locally. The Subcommittee recommends that the State of Minnesota should target its loan guarantee program to the midrange of the second segment (i.e., 5 to 10 mmgpy). The third segment is the small farm scale system. Although these plants are not as efficient as the large plants, the substantial feedstock price advantages could make these potential plants cost competitive. However, the small scale technology has not yet proven itself.

APPENDIX B - PLANT DESCRIPTION

A. BASIC PROCESS DESCRIPTION

The design criteria for an ethanol plant is based on site conditions and on operating parameters that are dictated by plant size, raw materials, and local marketing requirements. However, this Appendix outlines the basic ethanol production process. There are essentially seven steps to producing ethanol from grain: 1) grain milling, 2) mash preparation, 3) fermentation, 4) liquid/solid separation, 5) ethanol recovery, 6) ethanol dehydration, and 7) high protein feed processing. (See Figure B-1)

Milling

In a dry milling process the milling of starch grains is required to expose the starchy substrate of the grain to the processing media. Grain feedstocks are normally ground to an average particle size of 0.42 mm. The milled grain is then transferred to surge bins for subsequent introduction into the process.

Mash Preparation

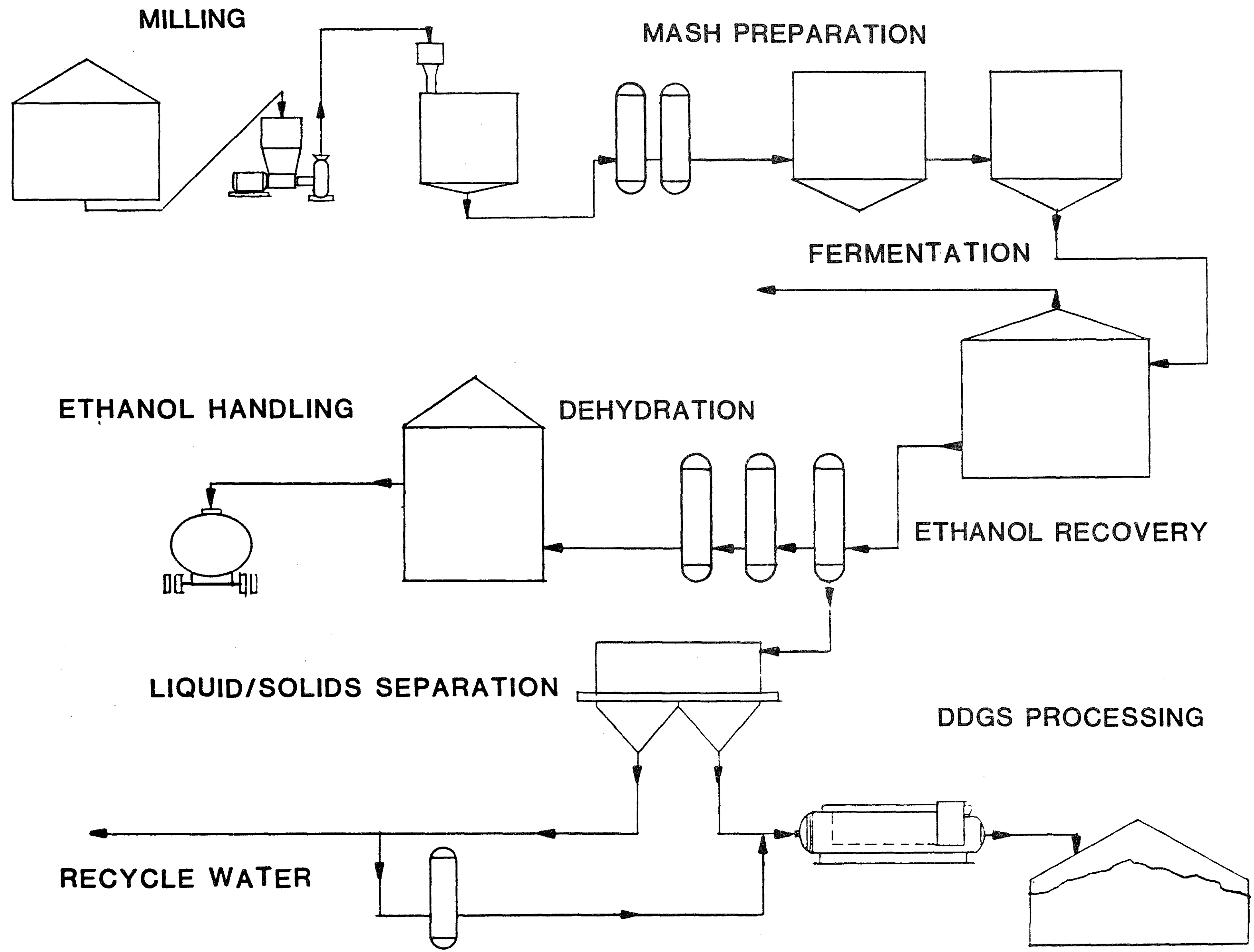
Preparation of the starch grains for fermentation is the key process in an ethanol plant. The first step in this preparation process involves the sterilization and gelatinization of the starch. Sterilization of the grains is essential for controlling the microbiological environment in ethanol fermentation. Gelatinization of the grain occurs simultaneously with sterilization and results in the solubilization of the starch substrate. Solubilization of the starch renders the substrate vulnerable to enzymatic processing of the starch into simple sugar (saccharification) for fermentation.

Saccharification of the grain starch to fermentable sugar is accomplished by utilizing a dual enzyme conversion system. The first enzyme acts to break down the large starch polymer (a large complex sugar molecule) into smaller sugar molecules (dextrins). Reaction conditions are carefully controlled to provide for optimal activity of the enzymatic reaction.

A second enzyme is added to the media and reacts with the dextrins and hydrolyzes the dextrin (a complex sugar) to produce glucose (a simple sugar). After these enzymatic processing steps, the glucose rich media is introduced to the fermenters for ethanol production via fermentation.

The use of sugar based feedstocks, such as sugar cane or sugar beets, enables the cooking and hydrolysis to be omitted. The sugar syrup can be fermented directly following a preparation and sterilization step.

FIGURE B-1
ETHANOL FERMENTATION- PROCESS SCHEMATIC



Fermentation

Fermentation simply means harnessing microbiological activity to produce useful products. The glucose in the mash is converted to ethanol in either a continuous or a sequential batch fermentation process utilizing standard brewers yeast. Fermentation cycles can range from 45 to 72 hours. Rapid fermentations can be obtained through innoculation with a high concentration of pre-conditioned yeast, batch agitation and precise control of batch conditions. In fermentation, yeast consume glucose through anaerobic respiration and produce roughly equivalent amounts of ethanol and carbon dioxide. This respiration process generates a significant amount of heat which must be removed to maintain constant temperature conditions. Final concentration of ethanol in the fermentation substrate can range from 6% to 10% by weight depending on the process.

The fermentation process produces large quantities of CO_2 gas. The carbon dioxide can be recovered and liquefied for sale for additional revenues.

Liquid/Solid Separation

After fermentation, the protein solids and the ethanol must be recovered from the mash. The conventional liquid/solid separation method involves fermenting the entire mash and transferring the fermentation substrate, including the solids, to a first stage distillation (stripping) column. The ethanol and a portion of the liquids are recovered from the stripping column as a vapor and transferred to the second stage (rectifying) column for ethanol recovery. The solids and remaining liquids are removed from the bottom of the stripping column where the solids are separated from the liquids and then dried and sold as protein feeds. Other more advanced separation techniques, such as separation prior to fermentation and separation prior to distillation, are under development. These new developments will increase plant efficiency.

Ethanol Recovery

The primary step in the ethanol recovery process is binary distillation. In this process, a fermented beer is introduced into a stripping column where the ethanol is stripped and concentrated from the aqueous media. The ethanol rich vapor from the stripping section is transferred to a rectifying column where the ethanol is concentrated to approximately 95% by weight. High pressure steam is usually utilized to provide the driving force for the ethanol concentration process. While this process was previously considered to be energy inefficient, the current use of sophisticated heat recovery techniques have resulted in distillation being very energy efficient (as compared to the previous beverage distilling technologies). The aqueous spent beer, or stillage, exits the bottom of the stripping column and is transferred to other processing operations.

Ethanol Dehydration

After the ethanol is recovered from the mash it still contains at least 5% water. Nearly anhydrous (i.e. containing not more than 1% water) ethanol is required for blending with gasoline and for many industrial uses.

Ternary distillation, which includes both azeotropic and extractive distillation technology, and water adsorption drying are the established methods of removing the remaining 5% water and obtaining anhydrous ethanol. The azeotropic process is the most widely used today since it is both reliable and energy efficient.

Azeotropic distillation employs the use of a low boiling entraining solvent. The addition of an entraining solvent effectively breaks the ethanol/water azeotrope and forms a three component (ternary) azeotrope which entrains more water than ethanol on a solvent free basis. Since the entraining solvent is immiscible with water, the water or aqueous phase is easily separated from the solvent by simple decanting techniques. The remaining ethanol not entrained with the solvent is virtually an anhydrous product which exits the bottom of the column.

High Protein Feed Processing

The solids separated from the fermentation process contains high protein. Processing of the distillers grains is a strong function of an ethanol plant's marketing approach. An ethanol plant has the flexibility to produce either DDGS (Distillers Dried Grains w/ Solubles) or DGw/S (Wet Distillers Grains w/Solubles). In the production of DDGS a byproduct grain dryer is utilized to reduce the moisture content of the grains from 70% to 10%. The resulting dried material is then available for long-term storage and transport to more distant markets. On the other hand, production of DGw/S does not require further processing in a dryer. The solids resulting from the solid/liquid separation process are transported directly to nearby markets such as local feedlots. DGw/S is more difficult to store due to its relatively high tendency to spoil or freeze. In both cases, solubles from the evaporation processes are re-introduced to the byproduct as protein enhancement.

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B. PLANT FACILITIES

In addition to process equipment, there are a number of structures and facilities required to support ethanol production. Figure B-2 contains pictures of a model of a 5 mmgpy plant which exhibits the features of a typical plant. Table B-1 summarizes several of the major facility requirements of a 5 and 10 mmgpy sophisticated plant located in the Midwest.

TABLE B-1

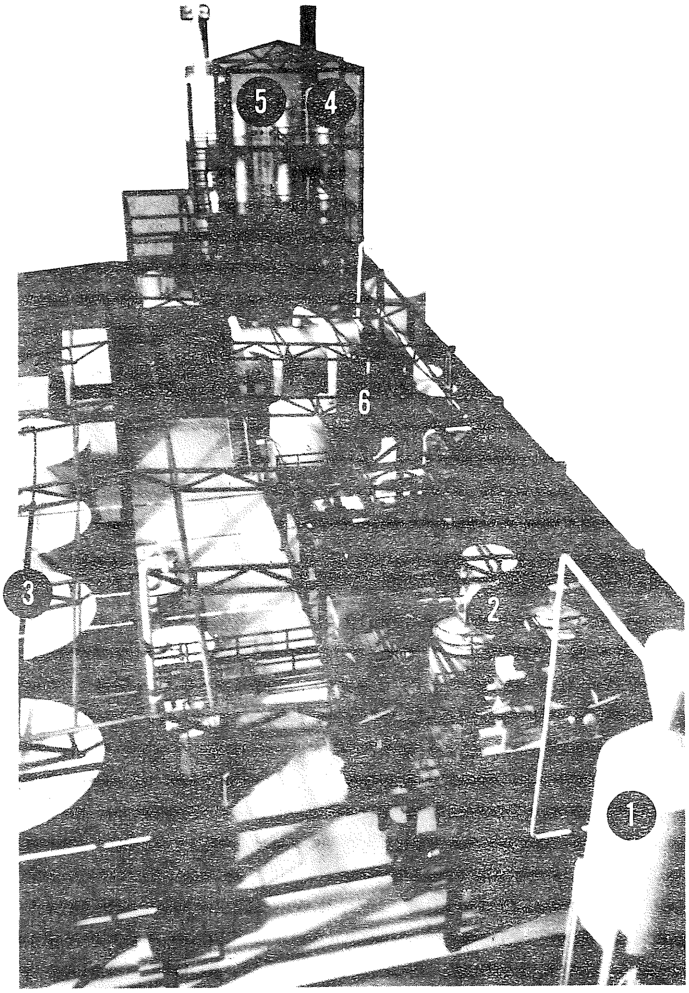
PLANT FACILITY REQUIREMENTS

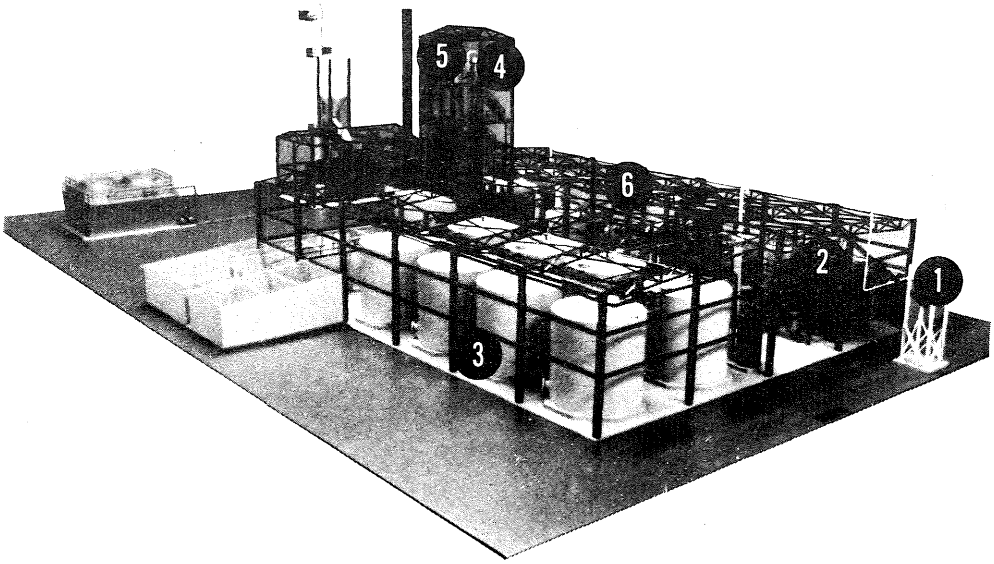
ITEM	5 mmgpy	10 mmgpy
<u>Storage</u>		
Grain	30,000 Bushels corn	60,000 Bushels corn
DDGS	400 Tons	800 Tons
Ethanol	105,000 Gallons	210,000 gallons
<u>Buildings</u>		
Main Process	16,000 Sq.Ft.	33,000 Sq.Ft.
Boiler	1,000 Sq.Ft.	1,500 Sq.Ft.
Other	900 Sq.Ft.	1,000 Sq.Ft.
<u>Land</u>		
Buildings & Grounds	6 acres	10 acres
Access Roads & Wastewater Ponds	4 acres	7 acres
<u>Boiler</u>		
Size	40,000 lb/hr steam	75,000 lb/hr steam
Fuel Consumption	12.2 Tons/year	22.9 Tons/yr
Fuel Type	13,000 Btu/lb coal	13,000 Btu/lb coal
<u>Utilities</u>		
Electrical	1,300 Kw/m	2,400 Kw/m
Water	115 g/m	100 g/m
Wastewater Discharge	60 g/m	100 g/m
<u>DDGS Production</u>	18,750 Tons/yr	37,500 Tons/yr
<u>Grain Consumption</u>	2 mm Bu/yr	4 mm Bu/yr

FIGURE B-2

PLANT MODEL

The plant will use established processes for the production of the ethanol and the recovery of the resultant by-products. The six basic production steps which the plant will generally utilize are as follows: (1) grinding the grain or other substrate and mixing it with water; (2) cooking and adding enzymes to the grain to convert starchy materials into sugar; (3) fermentation of the resulting sugars to produce carbon dioxide and alcohol; (4) distillation of the fermented "beer" to separate the alcohol from the remaining stillage; (5) further distillation of the alcohol to remove virtually all of the remaining water; and (6) drying and evaporating the stillage, marking it suitable for animal consumption as distillers dried grains.





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