Senate Counsel & Research

G-17 State Capitol
75 Rev. Dr. Martin Luther King Jr. Blvd.
St. Paul, MN 55155-1606
(651) 296-4791
FAX (651) 296-7747

Jo Anne Zoff Sellner
Director

Senate
State of Minnesota

S.F. No. 4 - Minimum Ethanol Requirement (First Engrossment)

Author: Senator Dallas C. Sams

Prepared by: Greg Knopff, Legislative Analyst
phone: 651-296-9399 fax: 651-296-7747
e-mail: gregory.knopff@senate.mn

Date: February 1, 2005

The first part of the bill increases the minimum ethanol requirement in gasoline to 20 percent on January 1, 2012. This new 20 percent requirement will sunset on December 31, 2010, if by that date the Commissioner of Agriculture finds that 20 percent of the overall volume of gasoline sold in Minnesota is ethanol.

The second part of the bill establishes a goal for the State of Minnesota to have 20 percent of all liquid fuel sold in the state from renewable sources by 2015. The bill directs the Commissioner of Agriculture, in consultation with the Commissioner of the Pollution Control Agency and the Commissioner of Commerce, to identify and implement activities to promote the use of renewable liquid fuels to make the goal.

Section 1 [Technical Amendment] provides an expiration date for the current 10 percent ethanol requirement, if the 20 percent ethanol requirement is effective on January 1, 2012.

Section 2 [20 Percent Ethanol Requirement] increases the minimum ethanol requirement in gasoline to 20 percent on January 1, 2012. The 20 percent requirement will sunset on December 31, 2010, if by that date the Commissioner of Agriculture finds that 20 percent of the overall volume of gasoline sold in Minnesota is ethanol.

Section 3 [Petroleum Replacement Promotion]

Subdivision 1. [Petroleum Replacement Goal] creates a petroleum replacement goal for Minnesota of 20 percent of all liquid fuel sold to be from renewable sources by December 31, 2015.

Subdivision 2. [Promotion of Renewable Liquid Fuels] directs the Commissioner of Agriculture, in consultation with the Commissioner of the Pollution Control Agency and the Commissioner of Commerce, to identify and implement activities to promote the use of renewable liquid fuels. The activities must include:

(1) recommendations for incentives for installation of renewable liquid fuel dispensing equipment;

(2) obtaining federal approval for the use of 20 percent ethanol;

(3) recommendations for ensuring access to an adequate fuel supply for motor vehicles and small engine equipment;

(4) working with owners and operators of large corporate automotive fleets to increase their use of renewable fuels; and

(5) working to maintain an affordable retail price for fuels.

GK:dv

Senate Environment and Natural Resources Committee

Wednesday, February 2, 2005
12:00 Noon
Room 107 Capitol

AGENDA

S.F. 4-Sams: Gasoline minimum ethanol content requirement increase.

S.F. 181-Lourey: Carlton county Biauswah bridge and Roussain cemetery designations.

S.F. 260-Chaudhary: Youth personal flotation device use requirement.

A bill for an act

relating to agriculture; increasing minimum ethanol content required for gasoline sold in the state; establishing a petroleum replacement goal; amending Minnesota Statutes 2004, section 239.791, subdivision 1, by adding a subdivision; proposing coding for new law in Minnesota Statutes, chapter 239.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA:

Section 1. Minnesota Statutes 2004, section 239.791, subdivision 1, is amended to read:

Subdivision 1. [MINIMUM ETHANOL CONTENT REQUIRED.] (a) Except as provided in subdivisions 10 to 14, a person responsible for the product shall ensure that all gasoline sold or offered for sale in Minnesota must contain at least 10.0 percent denatured ethanol by volume.

(b) For purposes of enforcing the minimum ethanol requirement of paragraph (a), a gasoline/ethanol blend will be construed to be in compliance if the ethanol content, exclusive of denaturants and permitted contaminants, comprises not less than 9.2 percent by volume and not more than 10.0 percent by volume of the blend as determined by an appropriate United States Environmental Protection Agency or American Society of Testing Materials standard method of analysis of alcohol/ether content in motor fuels.

(c) This subdivision expires on January 1, 2012, if subdivision 1a is effective on that date.

Sec. 2. Minnesota Statutes 2004, section 239.791, is amended by adding a subdivision to read:

Subd. 1a. [MINIMUM ETHANOL CONTENT REQUIRED.] (a) Except as provided in subdivisions 10 to 14, on January 1, 2012, and thereafter, a person responsible for the product shall ensure that all gasoline sold or offered for sale in Minnesota must contain at least 20 percent denatured ethanol by volume.

(b) For purposes of enforcing the minimum ethanol requirement of paragraph (a), a gasoline/ethanol blend will be construed to be in compliance if the ethanol content, exclusive of denaturants and permitted contaminants, comprises not less than 18.4 percent by volume and not more than 20 percent by volume of the blend as determined by an appropriate United States Environmental Protection Agency or American Society of Testing Materials standard method of analysis of alcohol content in motor fuels.

(c) This subdivision expires on December 31, 2010, if by that date the commissioner of agriculture certifies and publishes the certification in the State Register that at least 20 percent of the volume of gasoline sold in the state is denatured ethanol.

Sec. 3. [239.7911] [PETROLEUM REPLACEMENT PROMOTION.]

Subdivision 1. [PETROLEUM REPLACEMENT GOAL.] The petroleum replacement goal of the state of Minnesota is that at least 20 percent of the liquid fuel sold in the state is derived from renewable sources by December 31, 2015.

Subd. 2. [PROMOTION OF RENEWABLE LIQUID FUELS.] (a) The commissioner of agriculture, in consultation with the commissioners of commerce and the Pollution Control Agency, shall identify and implement activities necessary for the widespread use of renewable liquid fuels in the state. Beginning November 1, 2005, and continuing through 2015, the commissioners, or their designees, shall work with representatives from the renewable fuels industry, petroleum retailers, refiners, automakers, small engine manufacturers, and other interested groups, to develop annual recommendations for administrative and legislative action.

(b) The activities of the commissioners under this subdivision shall include, but not be limited to:

(1) developing recommendations for incentives for retailers to install equipment necessary for dispensing renewable liquid fuels to the public;

(2) obtaining federal approval for the use of E20 as gasoline;

(3) developing recommendations for ensuring that motor vehicles and small engine equipment have access to an adequate supply of fuel;

(4) working with the owners and operators of large corporate automotive fleets in the state to increase their use of renewable fuels; and

(5) working to maintain an affordable retail price for liquid fuels.

[EFFECTIVE DATE.] This section is effective the day following final enactment.

Senator ..... moves to amend S.F. No. 4 as follows:

Page 2, line 18, after "date" insert ":

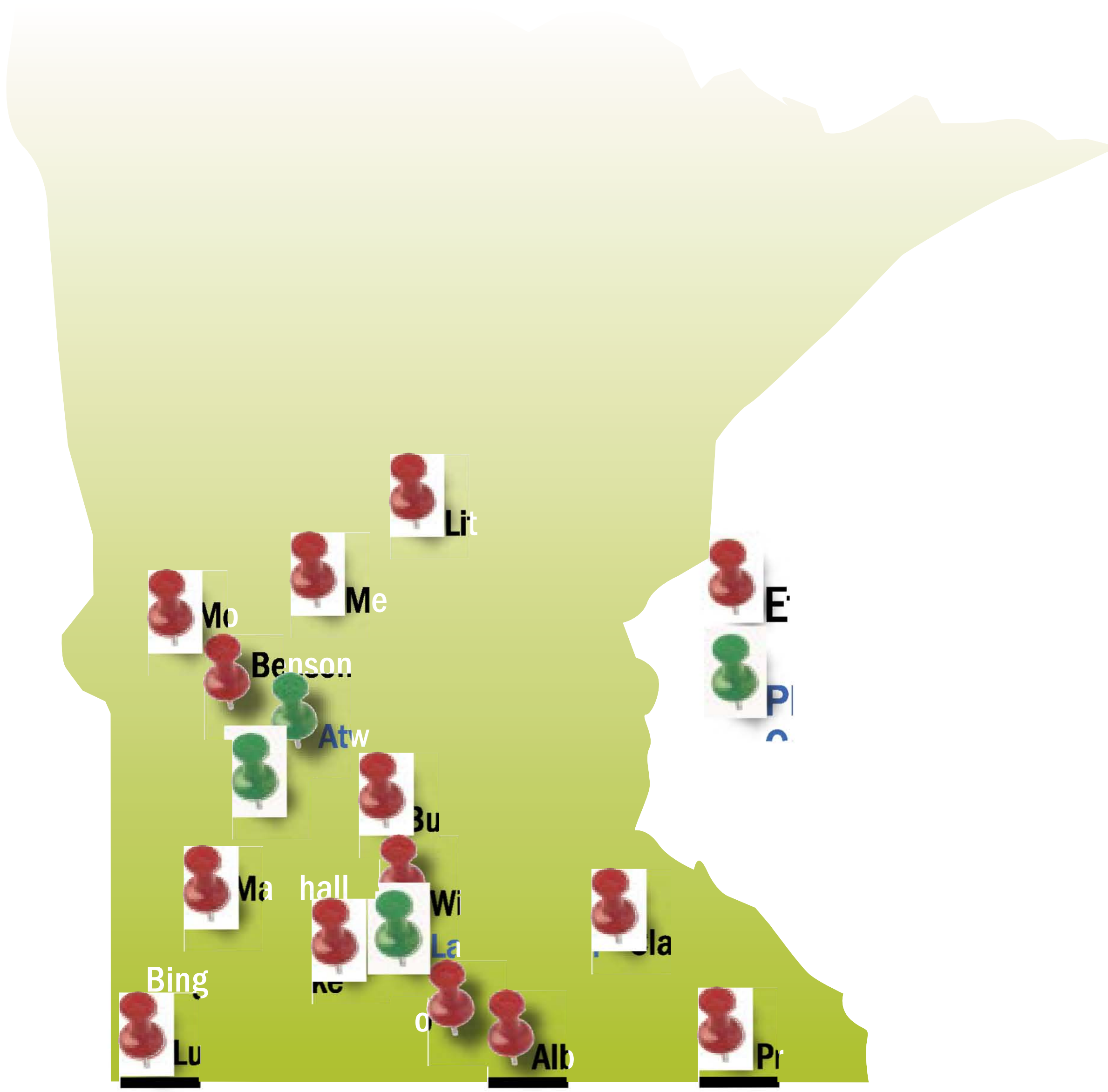
(1)"

Page 2, line 21, before the period, insert "; or

(2) federal approval has not been granted for the use of E20 as gasoline"

Ethanol Plants in Minnesota

January, 2005

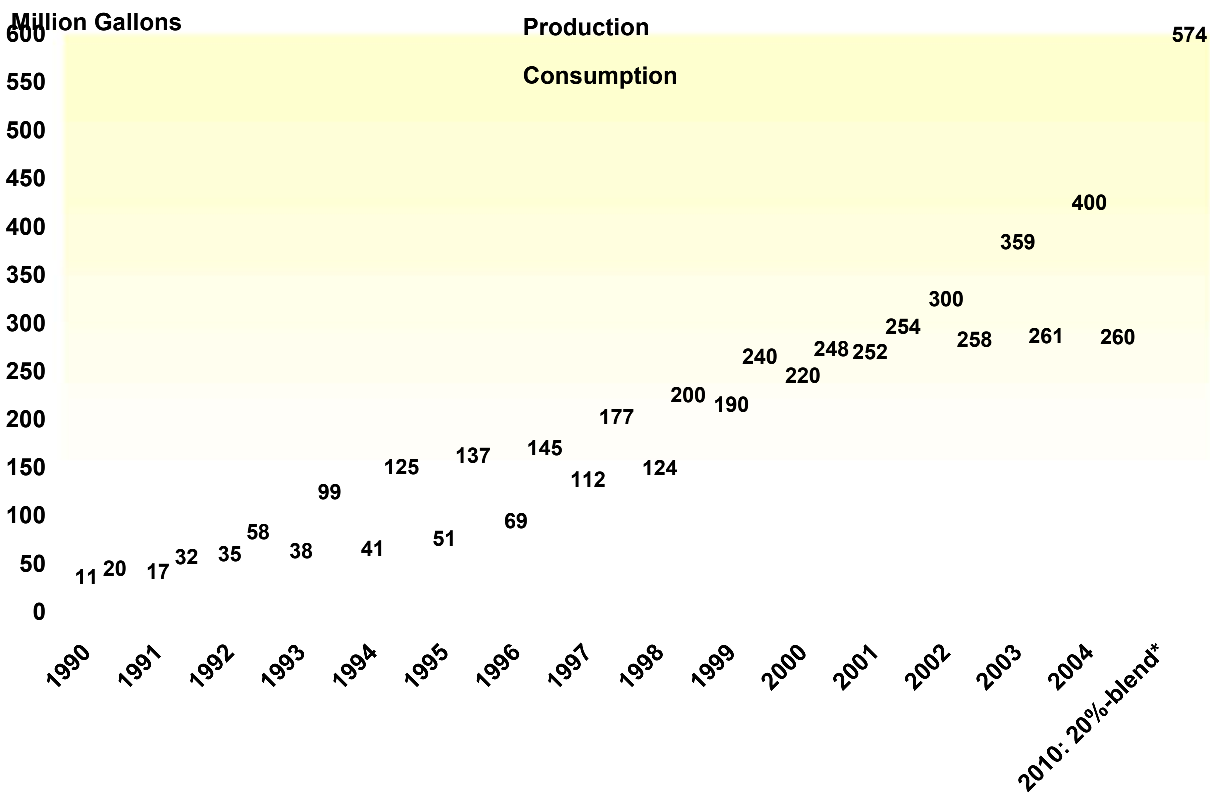


www.mda.state.mn.us

Minnesota Ethanol:
Production, Consumption, and Economic Impact

- Minnesota annually produces 400 million gallons of ethanol from 14 plants. About 260 million gallons are consumed in the state and the rest – 140 million gallons or 35% of Minnesota's total annual ethanol production – is exported.
- To meet the requirement of 20%-blend ethanol in all gasoline sold in Minnesota by 2010 as proposed by Governor Pawlenty, Minnesota would need 574 million gallons of ethanol. (This number is based on projected annual gasoline consumption growth trends from 2004 to 2010.)
- The proposed 20%-blend would require Minnesota to increase its ethanol production by 174 million gallons by 2010, about 44% increase over the current production level. The three new ethanol plants currently under construction have a combined production capacity of 150 million gallons, which would come into production by the end of calendar year 2005. That would bring Minnesota's ethanol production capacity to 550 million gallons five years before the 20%-blend implementation.
- Minnesota's ethanol industry generates an estimated $1.36 billion in total economic impacts and 5,300 jobs. The proposed 20%-blend ethanol by 2010 is projected to generate a total of $1.58 billion in economic impacts and 6,157 jobs.

Minnesota Ethanol Production and Consumption



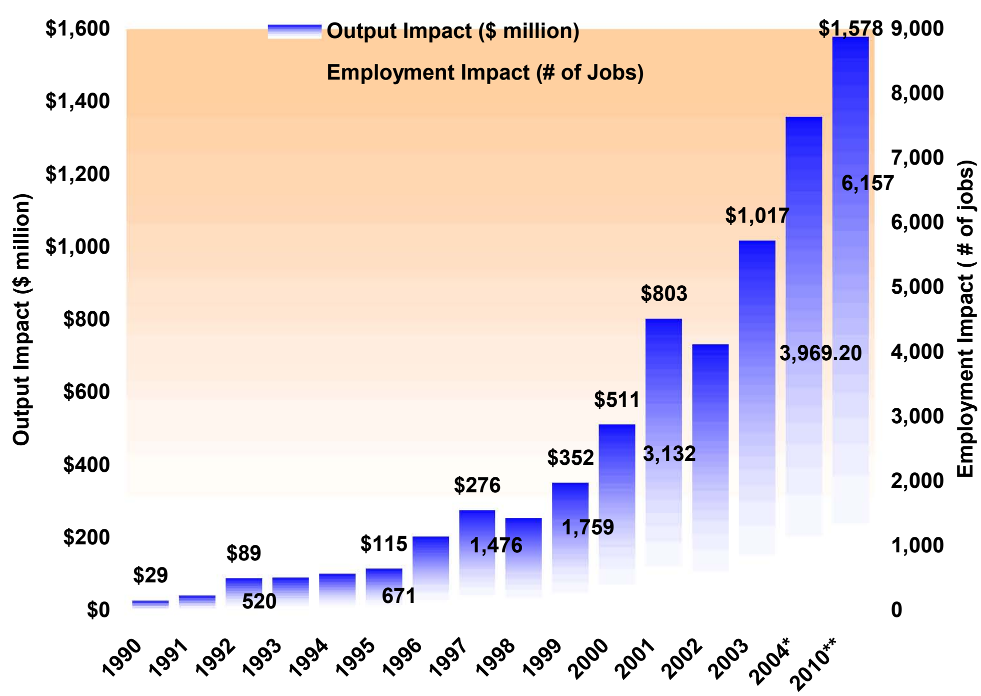
**Estimated consumption based on Gov. Pawlenty's proposed 20%-blend ethanol by 2010.*

Source: AMS, MDA

Minnesota Ethanol: Economic Impact

	Production (Million Gallons)	Output Impact ($ million)	Employment Impact (# of Jobs)
1990	11	28.51	166
1991	17	42.38	247
1992	35	89.30	520
1993	38	90.96	529
1994	41	101.45	590
1995	51	115.26	671
1996	69	203.51	1,089
1997	112	275.66	1,476
1998	124	254.38	1,362
1999	190	352.47	1,759
2000	220	511.48	2,231
2001	252	802.60	3,132
2002	300	732.24	2,858
2003	359	1,017.09	3,969
2004*	400	1,358.05	5,300
2010 (20%-blend)	***574***	***1,577.68***	***6,157***

Minnesota Ethanol: Output Impact & Employment Impact



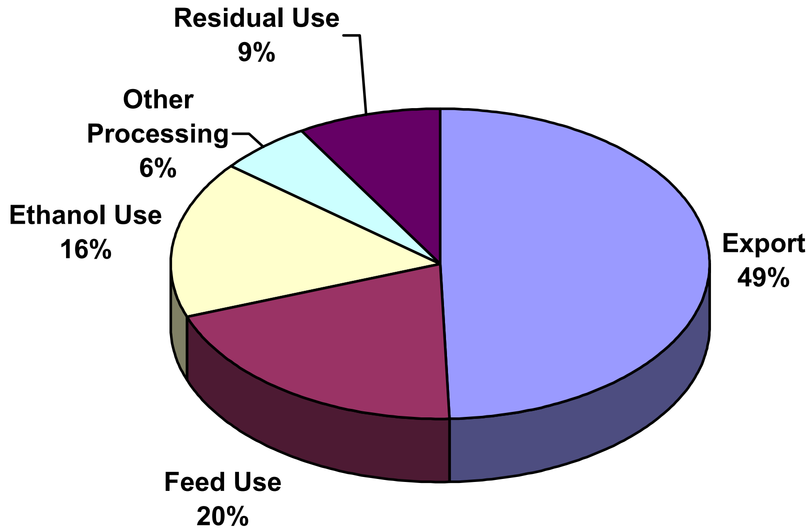
*Projected **Estimates based on Gov. Pawlenty's proposed 20%-blend ethanol by 2010

Source: AMS, MDA

Minnesota Ethanol: Corn Utilization

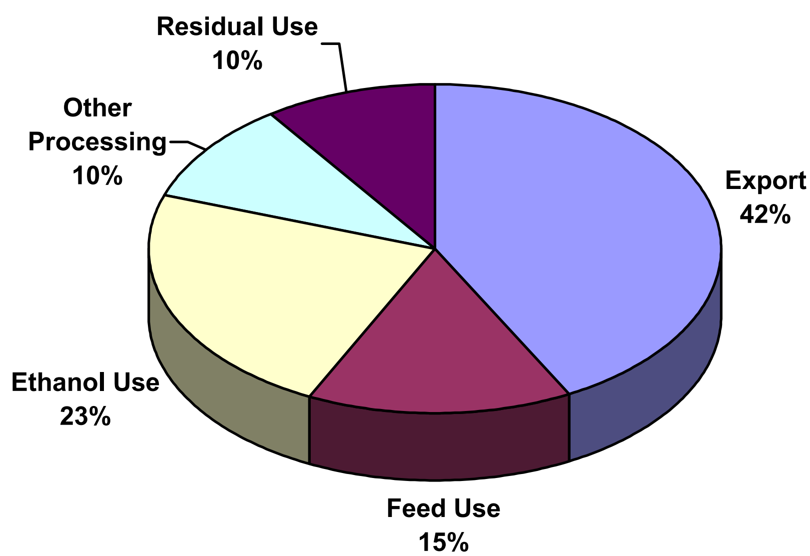
- In 2004, about 160 million bushels of corn was processed into ethanol, or one-sixth of Minnesota's total annual corn crop.
- By 2010, the proposed 20%-blend ethanol would require 230 million bushels of corn. If Minnesota's corn production remains at around 1 billion bushels per year, that would be about a quarter of the annual crop.

MN Corn Utilization (2004)



Source: PRX and MDA

MN Corn Utilization (2010 Projection*)



**Based on PRX data and MDA estimates*

MINNESOTA FARMERS UNION

Wednesday February 2nd, 2005

Chairman Marty, members of the Environment and Natural Resources Committee, on behalf of the members of the Minnesota Farmers Union, I urge your strong consideration for passage of S.F 4 authored by Senator Sams that would increase the minimum ethanol content in gasoline sold in Minnesota from 10 to 20%.

During my time serving in the House of Representatives, I was proud to be a leader in the House of ethanol and I am excited today to add our organizations strong support for this legislation.

Ethanol has been a true success story for rural Minnesota the years since we passed the 10% mandate.

- Farmers have enjoyed a higher price for corn near the ethanol plants. Most farmers have told me that they see a 10 to 15 cent per bushel spike since the plants have opened.
- Many of our farmers have laid out money of their own pocket to invest in ethanol plants and are pleased and proud of their investment.
- Minnesota's leadership and success has led to other renewable successes such as the 2% biodiesel mandate that will take affect this year. Farmers Union Marketing and Processing in Redwood Falls is already producing biodiesel and will be responsible for roughly 42% of the mandate alone.
- Ethanol plants have provided much needed, and well paying jobs in rural Minnesota.

I believe we can and must continue to champion ethanol here in the United States. I just returned from Brazil, where most of the cars use a 25% blend of ethanol, if they could do it, so can we. We have the ability to move forward with an energy policy that is RENEWABLE, not DRILLLABLE.

Thank-you,
Doug Peterson, President, MN Farmers Union

600 County Road D West • Suite 14 • St. Paul MN 55112-3521 • (651) 639-1223 • FAX (651) 639-0421

minnesota farm bureau federation

February 1, 2005

Senator Dallas Sams, Chair
Senate Environment, Agriculture and Economic Development Budget Division
328 State Capitol
St. Paul, MN 55155

Dear Chair Sams,

Minnesota Farm Bureau public policy strongly supports the expanded use of renewable fuels in Minnesota and our nation. Expanded use of renewable fuels is one of the priorities our members established for Farm Bureau's legislative activities during the 2005 session.

Farm Bureau public policy supports increasing the amount of ethanol in gasoline sold in Minnesota. We urge the committee to pass legislation today that will move Minnesota towards more usage of ethanol and other sources of renewable liquid fuels and less dependence on foreign sources of energy. In addition this legislation will continue to assist in building stronger communities in rural Minnesota.

Thank you for considering our policy in your deliberations today.

Sincerely,

Al Christopherson

Al Christopherson, President
Minnesota Farm Bureau Federation

Physical Address: 3080 Eagandale Place, Eagan, MN 55121-2118 Mailing Address: P.O. Box 64370, St. Paul, MN 55164-0370
Phone: 651.905.2100 Fax: 651.905.2159 e-mail: mfbf@aol.com www.minnesotafarmbureau.org

David Blatnik

DRAFT FINAL REPORT

Emission Reductions from Changes to Gasoline and Diesel Specifications in the Southeast Michigan Area

1.0 Executive Summary

Background

On April 15, 2004, the U.S. Environmental Protection Agency (EPA) finalized its list of 8-hour ozone nonattainment areas. Eight counties in Southeast Michigan were designated as a "moderate" nonattainment area. Under EPA rules, moderate areas have until 2010 to attain the 8-hour ozone standard. Moderate areas must also implement a vehicle inspection program if they do not already have one, and reduce ozone precursors by 15%.

Subsequently, the Southeast Michigan Council of Governments (SEMCOG) and the Michigan Department of Environmental Quality (MDEQ) requested a reclassification from the EPA to a marginal nonattainment area. EPA approved this request on September 15, 2004. Marginal areas are not required to implement vehicle inspection programs or implement a 15% reduction in emissions by 2010, but they must attain the ozone standard by 2007. SEMCOG's and MDEQ's request for reclassification did not change their commitment to attain the standard, but it did give them additional flexibility with regard to the control strategies it can pursue in order to meet the standard.

To ensure that the Southeast Michigan area attains the ozone standard as soon as possible, SEMCOG has been studying ways to reduce ozone precursors. As a part of this effort, it initiated a study of the emission reduction potential of different gasoline and diesel fuel formulations. SEMCOG formed a stakeholder group consisting of representatives with expertise from the oil industry, automobile industry, the Michigan Department of Agriculture and the Michigan Department of Environmental Quality to provide guidance to the study. SEMCOG contracted with Air Improvement Resource, Inc. (AIR) to quantify emission reductions that would result from various changes to fuels.

Method

In order to focus the study, the stakeholder group agreed to evaluate the emission reduction benefits of the following list of fuels and related controls. The options on the list were designed to provide a broad perspective of the emission reduction potential of various fuels. Nothing should be presumed about the feasibility or desirability of any option simply because it was analyzed in this study. For instance, several of the fuels studied are currently only available in California while several others are not manufactured or used anywhere in the United States.

Gasoline

- California reformulated gasoline (Ca RFG)
- Federal reformulated gasoline (RFG)
- Lower sulfur gasoline (10 ppm average)
- Lower volatility gasoline (limit of 7.0 psi Reid vapor pressure (RVP))
- A range of ethanol market penetrations (0 and 100% of a 10% ethanol blend)

Diesel

- California (CARB) diesel
- High cetane diesel
- Biodiesel (5% and 20%, or B5 and B20)
- In-use diesel engine particulate matter (PM) retrofits

The stakeholders desired that the study be as comprehensive as possible which, in some cases, included assessments of the same fuel using different modeling tools. These include EPA's MOBILE 6.2, NONROAD, and Complex models, as well as California's Predictive Model. The use of these different models allowed for a more complete perspective and provided users the opportunity to evaluate results in light of each model's strengths and weaknesses.

For each of the gasoline and diesel scenarios, expected fuel properties in Southeast Michigan were determined for the 2007 and later timeframe, taking into account controls required by the EPA. In the case of the gasoline scenarios, these fuel properties were used in the COMPLEX and Predictive Models to estimate the percent change in exhaust emissions of volatile organic compounds (VOC), oxides of nitrogen (NOx), carbon monoxide (CO), and fine particulate matter (PM2.5) from the Michigan baseline gasoline. These percent reductions were then applied to MOBILE6.2-generated exhaust emissions to estimate the changes in exhaust emissions. Changes in evaporative emissions, except permeation impacts of ethanol, were estimated directly with the MOBILE6.2 model. Emissions from off-road equipment and vehicle sources were estimated with the EPA NONROAD model.

A recent study by the Coordinating Research Council (CRC) indicates that ethanol increases permeation of VOC emissions from non-metal fuel systems found on on-road and off-road vehicles, other off-road equipment, and portable gasoline containers. Estimates of ethanol blends on permeation emissions from these sources were incorporated in this study, and these estimates utilized these CRC data in making these estimates.

Baseline Inventory

Baseline inventories for on-road and off-road sources are shown in Table ES-1. The table shows that VOC emissions from on-road sources will decline by 71 tons per day (40%) from 2002 to 2007, and that NOx will decline by 184 tons per day (40%). There are also significant reductions of VOC and NOx from off-road sources. The CO inventory for on-road vehicles is projected to decline very significantly, but CO from off-road sources is projected to increase somewhat. The majority of the emission reductions shown in Table ES-1 result from the phasing-in of existing federal regulations.

Table ES-1. Baseline On-Road and Off-Road Inventories for Southeast Michigan (Gasoline and Diesel – Tons per Summer Day)

	On-Road				Off-Road			
Year	VOC[1]	NOx	PM2.5[2]	CO	VOC[1]	NOx	PM2.5[2]	CO
2002	177	463	7.1	2412	66	69	6.1	1034
2007	106	279	4.2	1257	49	58	5.2	1119
2010	86	211	3.1	1094	40	48	5.1	1145
2015	62	114	2.0	906	35	40	5.1	1196
2020	54	71	1.6	848	35	40	5.3	1281

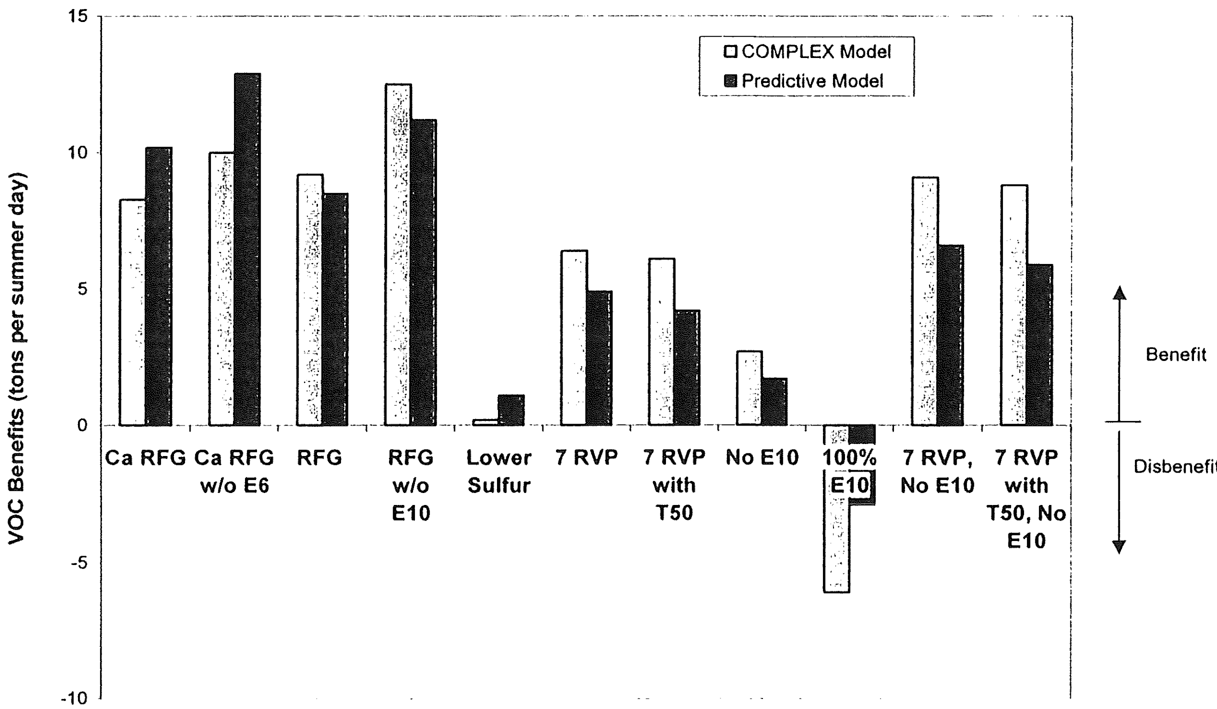
[1]Includes both exhaust and evaporative emissions but does not include any increase in permeation VOC emissions due to current ethanol market fraction of 25%.
[2]Exhaust emissions only

The VOC values in Table ES-1 do not include the increased permeation emissions from the portion of Southeast Michigan gasoline that contains ethanol (approximately 25%). At 25% market share, ethanol (E10) adds about 2 tons per day of VOC to the current inventory. If the ethanol market share were to increase from 25% to 100% (as assumed to be the case with Ca RFG or RFG), VOC permeation emissions would increase an additional 5.3 tons per day.

Results of Gasoline Analysis

The cumulative VOC and NOx benefits estimated in the study for the gasoline options are shown in Figures ES-1 and ES-2. Estimates are shown using two different models to predict exhaust emission changes - the EPA Complex Model, and the California Predictive Model. Results from the two models should not be averaged. They should instead be viewed as the range of likely benefits.

Figure ES-1. Net VOC Benefits in 2007 - All Sources (tons per summer day)



[1]Includes all exhaust and evaporative effects, including ethanol permeation, where applicable.
[2]Includes both on-road and off-road sources.
[3]E6 and E10 refer to the volume percent of ethanol in the gasoline. E6 denotes a 6% ethanol concentration; E10 denotes a 10% concentration. 100% E10 denotes 100% market share of E10 fuel.
[4]*7 RVP with T50* is a low volatility sensitivity case in which T50 is assumed to increase by 3°F as a result of the lower RVP.
[5]The reduction benefit of lower volatility fuels is expected to be higher than shown above because the NONROAD model does not currently account for the evaporative benefit of lower volatility fuels for off-road vehicles and equipment.

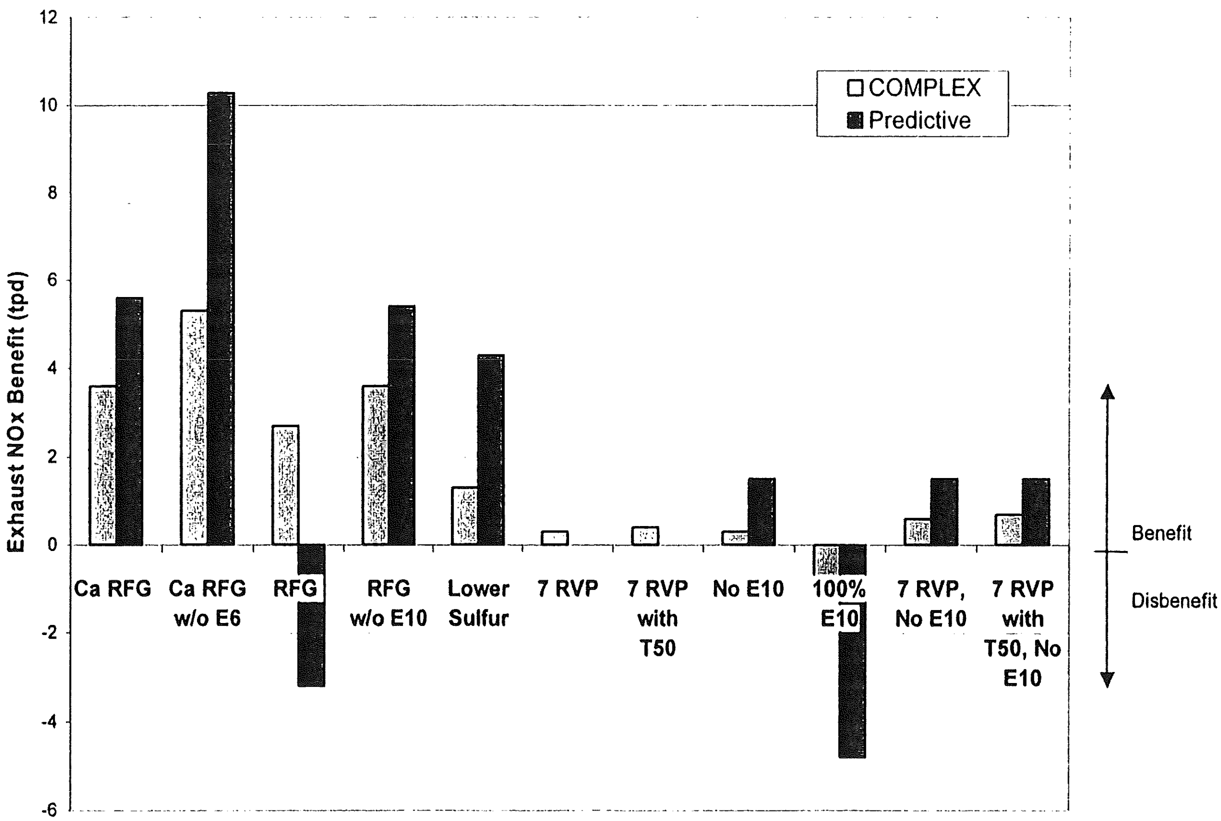
Findings and Observations Regarding Gasoline VOC Emissions:

- California RFG and Federal RFG provide the greatest VOC reduction benefits.
- The benefits of both RFG programs are reduced when ethanol is used, due to the increase in permeation VOC emissions caused by ethanol.
- Lower volatility fuels (7 RVP and 7 RVP with T50) also provide significant reductions, roughly half the benefit of reformulated gasoline.
- If the T50 level of lower volatility (7 RVP) fuel increases, the Predictive Model indicates the overall VOC benefit will be reduced.
- If ethanol were not used at all in Southeast Michigan (No E10 option), VOC emissions would be lower due to the elimination of ethanol-induced permeation and

the reduced evaporative emissions due to lower average volatilities (ethanol currently receives a 1.0 psi waiver).

- The benefits of 7 RVP can be added to the benefits of no ethanol. The benefits of the combined options are a little less than the reformulated gasoline options.
- Retaining the current gasoline program, and increasing the ethanol market share to 100% (100% E10 option) shows a significant VOC increase due to increased permeation.
- The VOC benefits shown in all the lower volatility options in Figure ES-1 (Ca RFG, RFG, 7 RVP, and 7 RVP with T50) are understated because EPA's NONROAD model does not currently account for the evaporative benefits of lower volatility fuel for off-road equipment and portable containers. These benefits are expected to be significant.

Figure ES-2. Net NOx Exhaust Benefits in 2007 - All Sources
(tons per summer day)



[1]Includes both on-road and off-road sources.

Findings and Observations Regarding Gasoline NOx Emissions:

- Emission reduction benefits are highest for the two California RFG options.
- The Predictive Model estimates significantly greater NOx benefits than the Complex Model for the California RFG and Lower Sulfur options. In general, the Predictive Model is thought to provide better results as it uses more recent data on the impacts of sulfur on exhaust emissions.
- For Federal RFG, the Complex model predicts a NOx benefit, while the Predictive Model shows a disbenefit. While EPA and the California Air Resources Board both agree that ethanol produces a NOx disbenefit in 1988-1995 light duty vehicles, only the Predictive Model currently takes this into account. Therefore, it is generally believed to provide better NOx emissions estimates for fuels containing ethanol. It should be noted that the Predictive Model also assumes an ethanol-related disbenefit for 1996 and newer vehicles. As of the writing of this report, it is our understanding that EPA believes the data on these vehicles is not conclusive.
- Both the RFG without ethanol and lower sulfur options show sizeable NOx benefits.
- Lower volatility fuels (7 RVP & 7 RVP with T50) have little or no effect on NOx.
- For the No E10 option, i.e. no ethanol would be used in Michigan, the Predictive Model shows a small NOx benefit.
- For the 100% E10 option, i.e. all Southeast Michigan gasoline would be 10% ethanol, the Predictive Model shows a significant NOx disbenefit.

It should be noted that, while most of the gasoline options tested could not be implemented in combination with one another, the 7 RVP and lower sulfur options are not necessarily mutually exclusive. In this case, the VOC and NOx emission benefits would be additive.

Carbon monoxide (CO) inventory changes for the various gasoline fuel options are shown in Table ES-2.

Table ES-2. Net CO Benefits - All Sources (tons per summer day)

Year	CaRFG	CaRFG w/o E6	RFG	RFG w/o E10	Low RVP, Low sulfur	100% E10	No E10
2007	125	-83	273	-83	0	265	-83
2010	122	-81	264	-81	0	257	-81
2015	123	-81	266	-81	0	260	-81
2020	128	-85	277	-85	0	272	-85

[1]Includes both on-road and off-road sources.
[2]CO changes were estimated using EPA's MOBILE6.2 model, and adjusting the inputs for percent ethanol, ethanol concentration, RVP, and waiver status.

Findings and Observations Regarding Gasoline CO Emissions:

- Ca RFG, RFG, and 100% E10 fuel scenarios would significantly reduce both on-road and off-road CO emissions.

- If ethanol were not utilized in Michigan (No E10 option), CO emissions would increase by roughly 80 tons per day.

Gasoline sulfur also affects CO, but this analysis did not estimate the impact of changes in gasoline sulfur level on CO emissions due to the lack of analytical tools. Both Ca RFG and the low sulfur fuel option would show an increase in CO benefits if this factor were included.

Findings and Observations Regarding Other Gasoline Pollutants

- California and Federal RFG, with or without ethanol, would provide significant toxic emission reduction benefits.
- Lower sulfur and lower RVP would provide some small toxic emissions benefits.
- California RFG and low sulfur fuel would provide some small exhaust PM2.5 benefits due to the reduction in sulfur levels from 30 ppm to about 10 ppm.

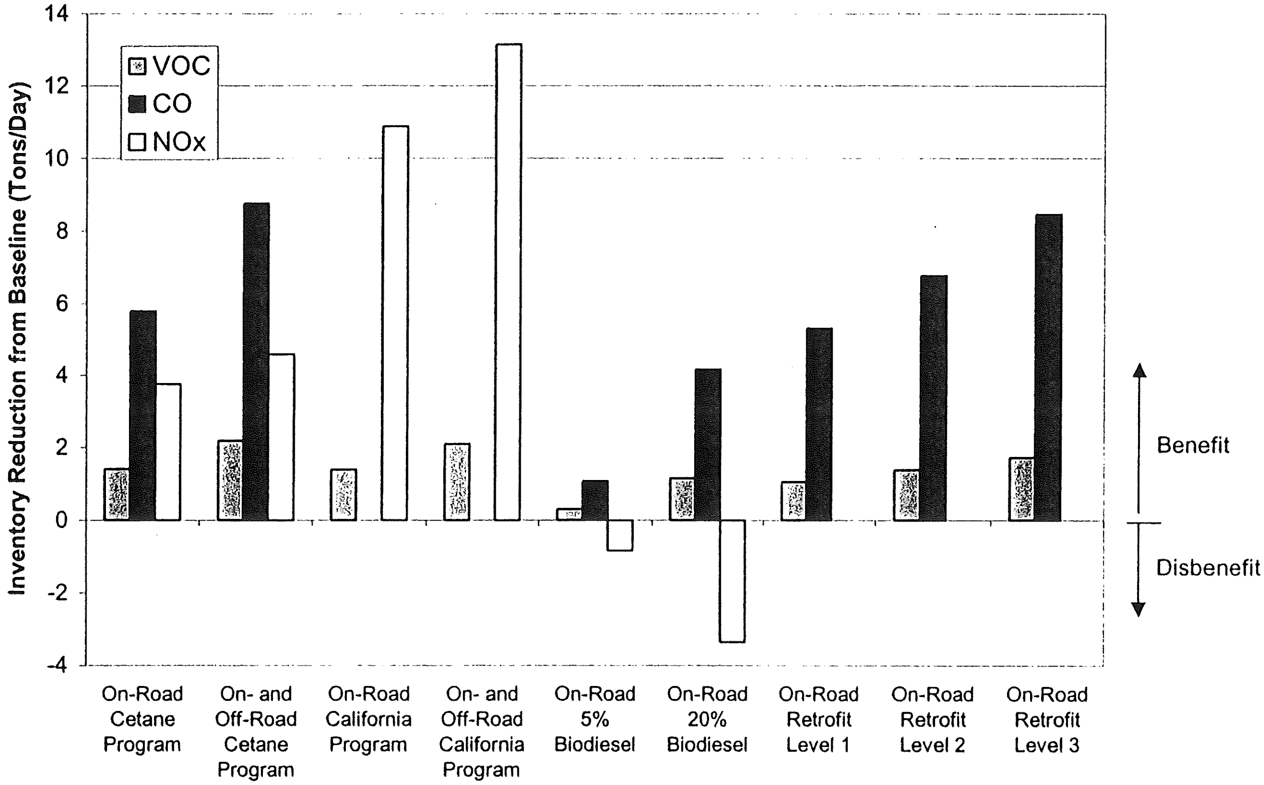
Results of Diesel Analysis

Figure ES-3 summarizes the 2007 VOC, CO and NOx emissions benefits from the different diesel programs.

Findings and Observations Regarding Diesel VOC, NOx and CO Emissions:

- As with gasoline, the emission reduction benefits of different diesel formulations vary significantly. The largest reductions come from California diesel, which yields over twice the NOx benefit of the high cetane option
- VOC benefits range from 0.3 tons/day for the 5% biodiesel program to just over 2 tons/day for the cetane and California diesel programs that cover both on- and off-road diesel.
- NOx benefits range from a 3 ton per day increase for the 20% biodiesel program to roughly a 13 ton per day reduction estimated for the on- and off-road California diesel program.
- Biodiesel produces the least VOC and CO emissions benefit of all the diesel options and has a NOx disbenefit, which increases as the "bio" fraction increases.
- There are no measurable NOx benefits from diesel retrofit programs.
- None of the diesel options produce significant VOC emission reductions.

Figure ES-3. Summary of Inventory Benefits of Diesel Programs VOC, CO and NOx in 2007



[1]Each program was assumed to achieve 100 percent implementation or coverage over the 7-county SEMCOG region. As such, all applicable diesel engines would operate under the specifics of each program.
[2]No data or equations were provided by EPA for estimating CO benefits from California Diesel, therefore, CO impacts for this fuel were not modeled.
[3]Because available data for off-road bio-diesel benefits is inconclusive and very few retrofit technologies have been approved for off-road use, off-road emissions benefits were not modeled for these programs.

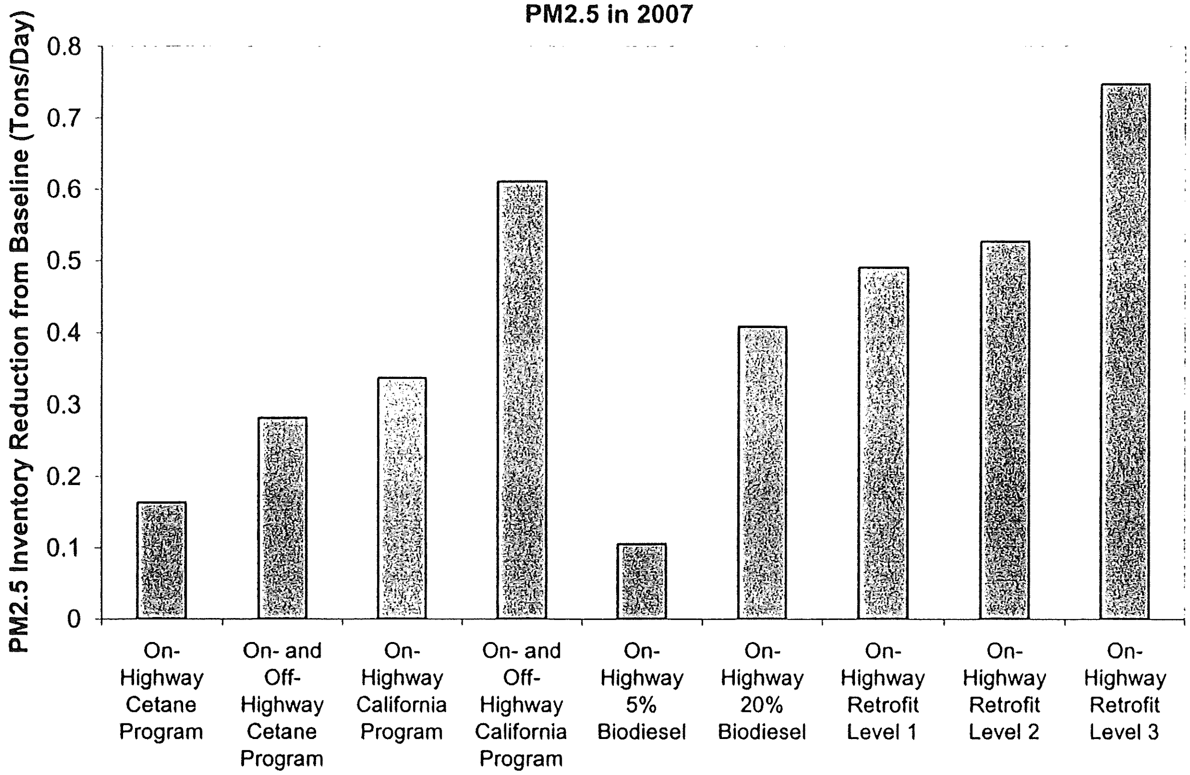
Findings and Observations Regarding Diesel PM2.5 Emissions:

Figure ES-4 summarizes the 2007 PM2.5 exhaust emissions benefits from the various diesel options. Benefits were estimated relative to the Baseline mobile source inventory, which for PM2.5 in 2007 is estimated at 9.4 tons/day for all diesel equipment and vehicles.

- As with NOx, the largest PM2.5 reduction comes from California diesel, which yields over twice the benefit of the high cetane option.
- Overall, benefits range from roughly 0.1 tons per day for the 5% biodiesel program to nearly 0.8 tons per day for the Level 3 diesel retrofit program.
- On a percentage basis, the PM2.5 benefits range from 2 to 11 percent of diesel emissions.

- The diesel retrofit options show a comparatively high PM2.5 benefit. However, these values assume 100% implementation on all vehicles operating in the region, while surveys indicate only 36% of truck activity in the region is from centrally-fueled, local fleets.

Figure ES-4. Summary of Inventory Benefits of Diesel Programs PM2.5 in 2007



[1]For the purpose of this study, each program was assumed to achieve 100 percent implementation or coverage over the 7-county SEMCOG region. As such, all applicable diesel engines would operate under the specifics of each program.
[2]Because available data for off-road bio-diesel benefits is inconclusive and very few retrofit technologies have been approved for off-road use, off-road emissions benefits were not modeled for these programs.

General Findings and Observations:

In addition to the specific findings and observations by pollutant and fuel, some other noteworthy results to be considered in policy discussions that might follow this report are listed below.

- Currently available tools for estimating benefits of different fuels have limitations and, in some cases, predict very different results. Nonetheless, through careful application of model inputs and cautious interpretation of model outputs, a good understanding of the range of impacts of different fuel configurations was achieved and is summarized in this report.

- The vast majority of emission reductions from mobile sources between 2002 and 2007 (40% in VOC and 40% in NOx) will result from the phasing-in of existing federal regulations, most notably, more stringent vehicle emission standards and reduced sulfur in both gasoline and diesel fuel. Potential emission reductions from the fuel strategies studied are relatively small when compared to the decrease in the mobile source inventory and will decrease with time beyond 2007 as the overall mobile source inventory decreases.
- Generally, the gasoline fuel options produce higher VOC benefits while diesel options can produce the highest NOx benefits and also decrease PM2.5 emissions.
- Different fuels produce a wide range of benefits, and in some cases disbenefits, for each of the pollutants evaluated. Therefore, the best fuel option, or combination of options, will depend on which pollutants need to be reduced, how much reduction is needed, what it will cost, and when it can be implemented. The data in this report should be combined with other information as part of the policy decision on which new fuels, if any, to select.

Figure 8a. Net VOC Benefits - All Sources (tons per summer day)

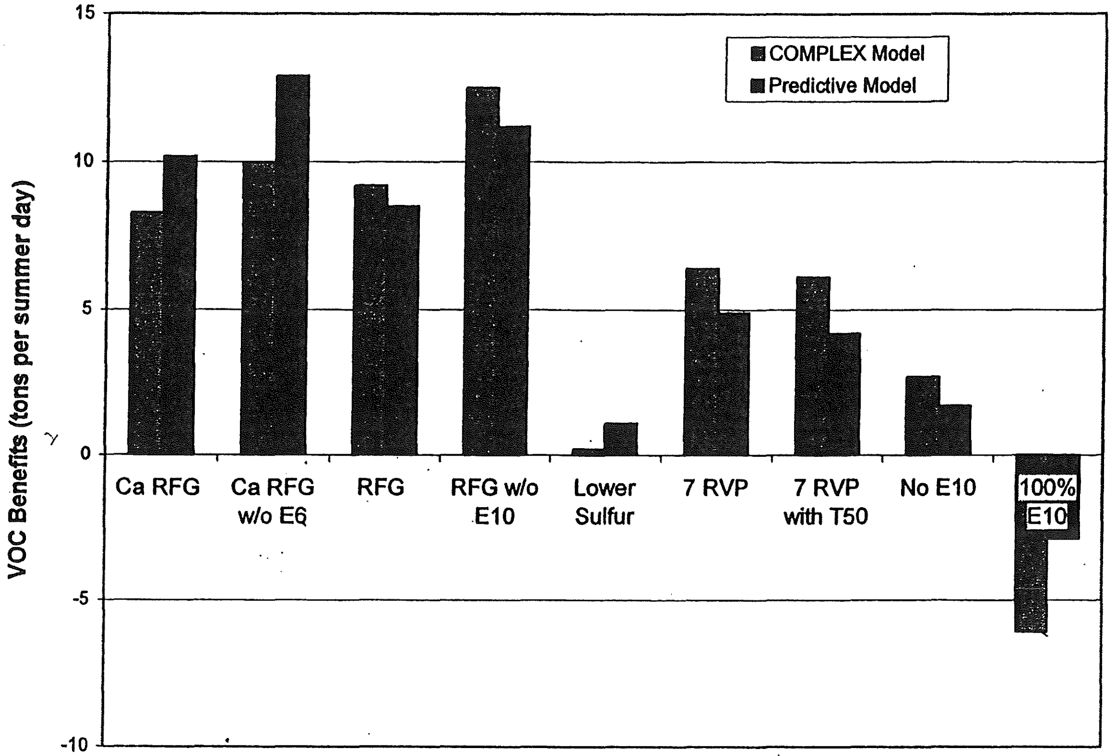
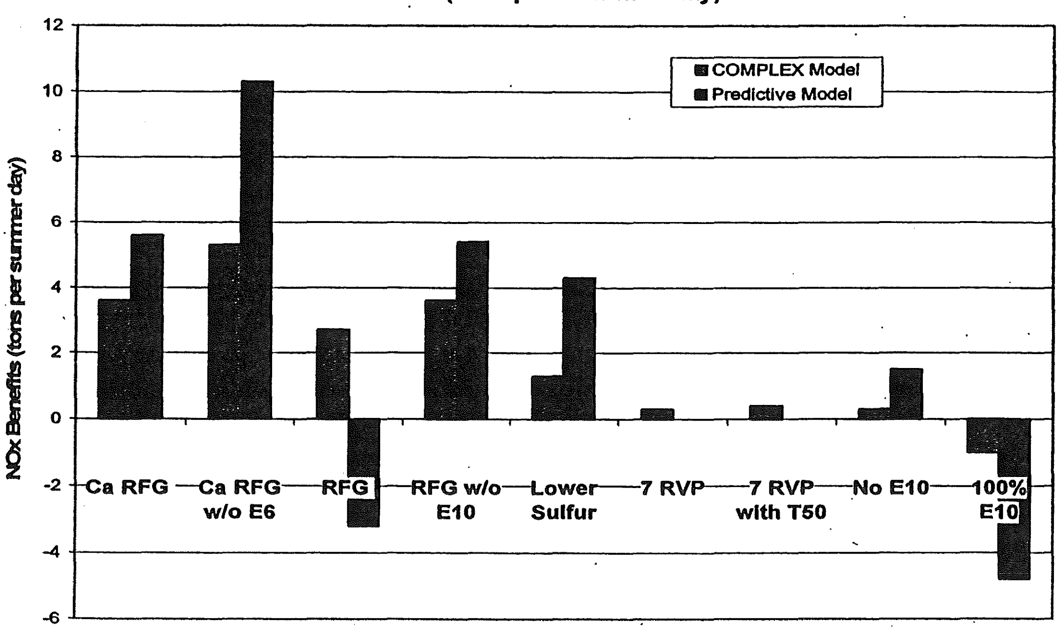


Figure 8b. Net NOx Benefits in 2007 - All Sources (tons per summer day)



Ethanol and Air Quality in Minnesota

Joel Schwartz
Visiting Fellow
American Enterprise Institute
February 2005

jschwartz@aei.org

Air Pollution and Ethanol in Minnesota

- Ethanol increases ozone-forming emissions
  - Ethanol worsens ozone by increasing ozone-forming volatile organic compound (VOC) emissions, and possibly nitrogen oxides (NOx)
  - Ethanol reduces CO emissions, but CO is already far below federal standard, and continues to drop
- Minnesota attains all federal air quality standards, but small margin of safety for ozone
  - Hot, sunny summer creates risk of non-attainment over next few years
  - Why risk increasing ozone when ozone non-attainment is so costly?
- Even if ethanol improved air quality, it is far more costly than other options for ozone reduction
- Vast majority of automobile pollution reductions are due to better technology on vehicles and lower sulfur in fuel
  - One year of fleet turnover reduces CO by same amount as entire ethanol CO benefit
- Long-term problem already solved by inherently cleaner cars
  - Average automobile emissions are dropping about 10%/year
  - Fleet will be 80% cleaner in about 15 years (after including growth)

Ozone and CO Trends

- CO: From 1994-2004, CO on worst day at worst site in MN dropped more than 80%
  - Worst location is now 70% below federal standard
- Ozone: Peak ozone levels are declining very slowly
  - Worst location has one or two 8-hour ozone exceedances in most years
  - Averaging four exceedances per year puts you in non-attainment
- What role did oxygenates play
  - CO: Maximum of about 10%-15% of CO improvement is due to ethanol, rest to technology
  - Ozone: would likely have improved more without ethanol, particularly the peak levels responsible for non-attainment
- 21st Century cars will eliminate ozone and CO issues over next decade as old-technology cars are retired

Ethanol and Vehicle Pollution

- Ethanol causes net increases ozone-forming emissions
  - Increases volatile organic compounds (VOC) and possibly nitrogen oxides (NOx)
    - VOC effects: greater tailpipe emissions; greater evaporation; greater permeation
  - Effect is greatest on hot days—the days most favorable for forming ozone
  - Data from Denver:
    - Doubling of average automobile tailpipe VOC emissions on hot days (>90F) due to ethanol
    - Doubling of emission test failure rate on hot days
    - Areas without ethanol do not experience higher emissions on hot days
- Minneapolis-St. Paul averages about 10 days/year above 90F
  - Risk of non-attainment if area gets string of hot summers
  - Lower risk without ethanol in gasoline
  - Non-attainment triggers requirements that would likely cost a few hundred million per year in direct costs, plus indirect costs of process- and administration-heavy requirements like New Source Review, Title V permitting, and transportation conformity
- California has the worst air pollution in the country. CA Air Resources Board is working hard to *remove* ethanol from CA gasoline

Ethanol Would Be A Poor Choice Even If It Reduced Ozone-Forming Emissions

- Ethanol is far more expensive and less efficient than other options for reducing automobile emissions
- Directly addressing high-polluting vehicles would provide more air quality benefits at far lower cost
  - Worst 5% of cars emit 50% of VOC emissions
  - Far more effective and cost effective to fix or scrap these cars

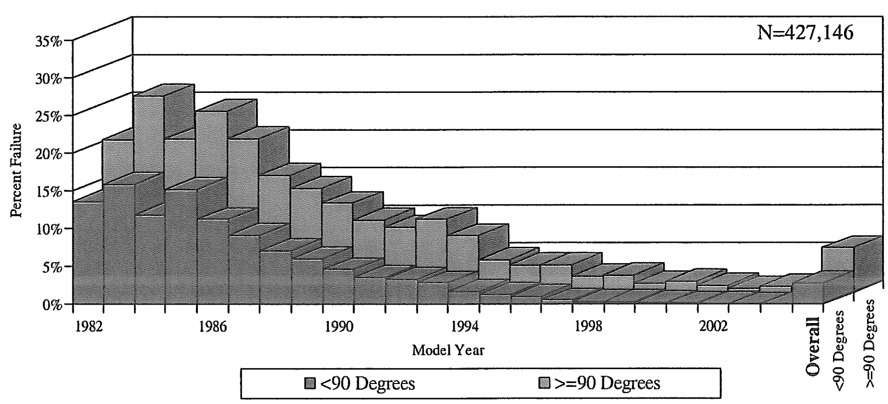
Paying Too Much

- Ethanol receives direct per-gallon subsidy of about $158 million/year due to Minnesota gasohol consumption
  - $21 million of this is from state taxpayer funds
- Fuel economy penalty of about 3% per gallon, costs Minnesotans 5.25¢/gallon, or $140 million per year statewide
  - Going to E20 would double this cost to $280 million per year
- Compare with cost of directly addressing high-polluting cars
  - For $140 million—one year's worth of fuel economy penalty costs—you could pay motorists driving the worst 2% of cars $2,600 each to scrap them
    - Permanent statewide automobile VOC reduction of more than 20%
    - Larger percentage reductions possible regionally, if program focused only on highest-ozone areas of state
  - High polluters can be identified with on-road remote sensing
- Ethanol would never be considered as an air quality measure on a pollution-reduction-per-dollar basis
  - Subsidies and fuel economy loss hide the real cost of ethanol relative to other options

Ethanol: Expensive and Counterproductive

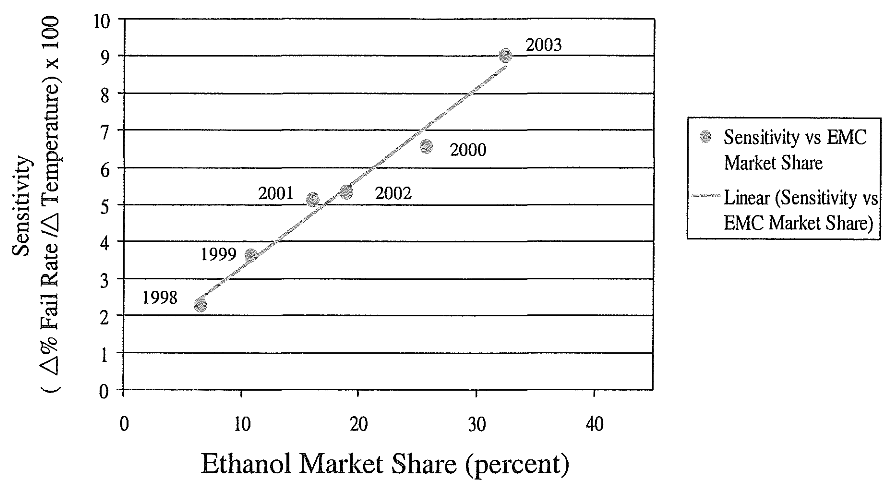
- Ethanol increases ozone-forming emissions
  - Why risk the economic harm from being designated non-attainment
  - VOC and NOx eliminated by fleet turnover
  - Achieve additional near-term reductions with targeted approaches
- Ethanol costs Minnesotans $140 million/year in fuel economy loss, and $21 million/year in state subsidies. Federal subsidies add another $137 million/year.
  - Minnesota could mitigate ozone non-attainment risk virtually permanently by instead spending a fraction of these funds on a one-time basis to address remaining middle-aged and older high-polluting, old-technology automobiles
- Oxygenates are not necessary for Minnesota to stay in CO attainment or to continue reducing CO
  - Fleet turnover has solved the problem and will continue to reduce CO
  - Targeted strategies just as effective and far cheaper should additional CO reductions be desired

More Cars Fail Emissions Test on Hot Days



Denver test results, 10/02-9/03. Graph provided by Don Stedman, U of Denver

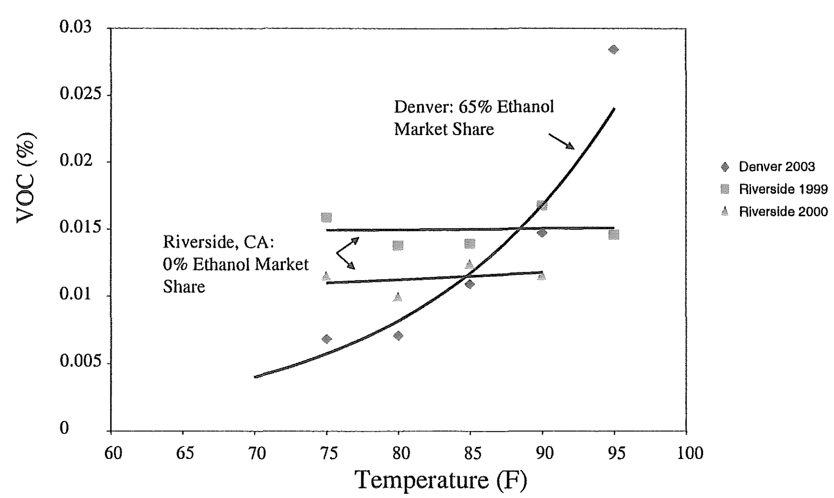
Sensitivity of Emissions to Temperature Is Correlated with Ethanol Market Share



Denver test results, 1998-2003. Graph provided by Don Stedman, U of Denver

9

On-Road Data Show Automobile VOC Emissions Rise on Hot Days Only in Areas with Ethanol



On-road remote sensing data. Graph provided by Don Stedman, U of Denver.

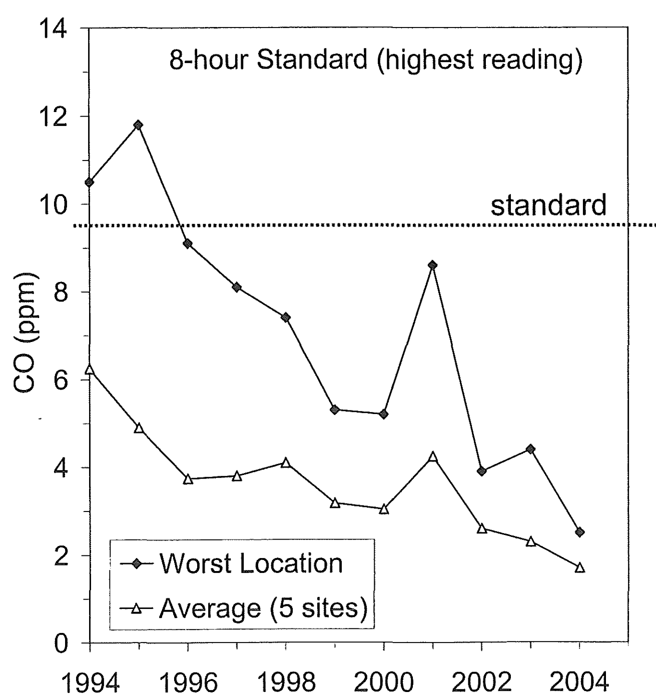
10

CO: Localized Approaches for A Localized Problem

- Almost all CO (90% or more) comes from gasoline engines, mainly automobiles
- High CO levels occur only at localized "hot spots"
- It takes 3 exceedance days in a 2-year period to violate the EPA standard
  - But even the worst location in Minnesota hasn't had even one exceedance in the last 10 years
- Minnesota will stay in attainment of the CO standard with or without oxygenated fuel
- But even if CO reductions were necessary, they would be necessary in perhaps one or two relatively small areas
- CO emissions are highly skewed—the worst 5% of cars emits 50% of CO emissions
  - Scrapping or repairing a few thousand (at most) high emitters in a CO hot-spot area would solve the problem.

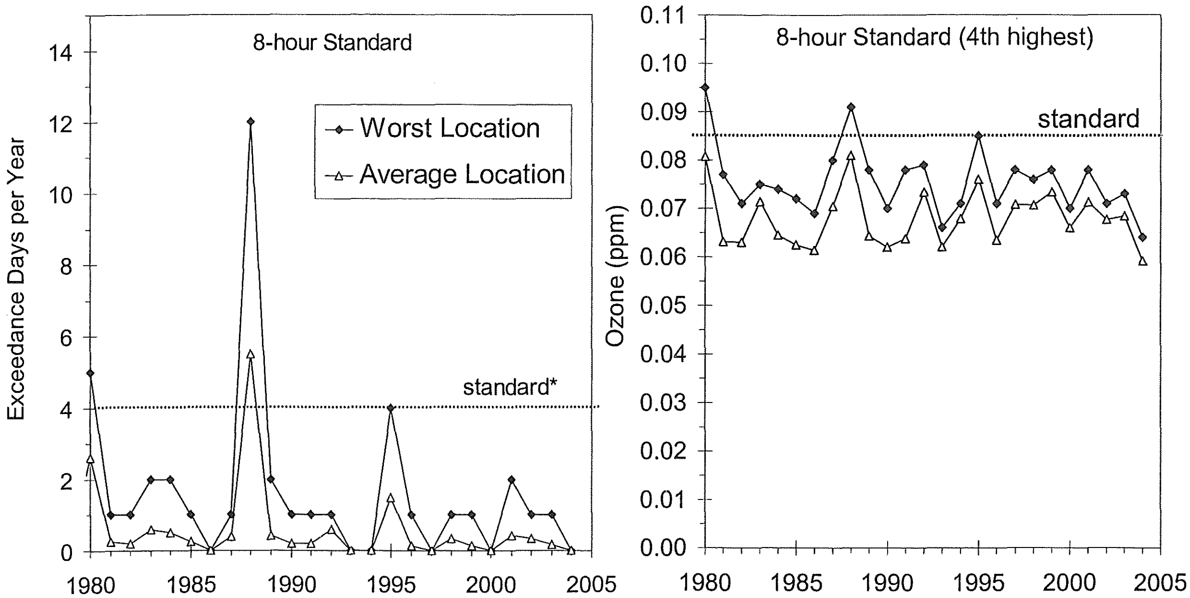
11

Carbon Monoxide Trend



Notes: "Worst location" is Minnesota site with highest value in any given year. "Average" is average for all Minnesota sites with continuous data for entire time period. All data downloaded from EPA's AIRdata system.

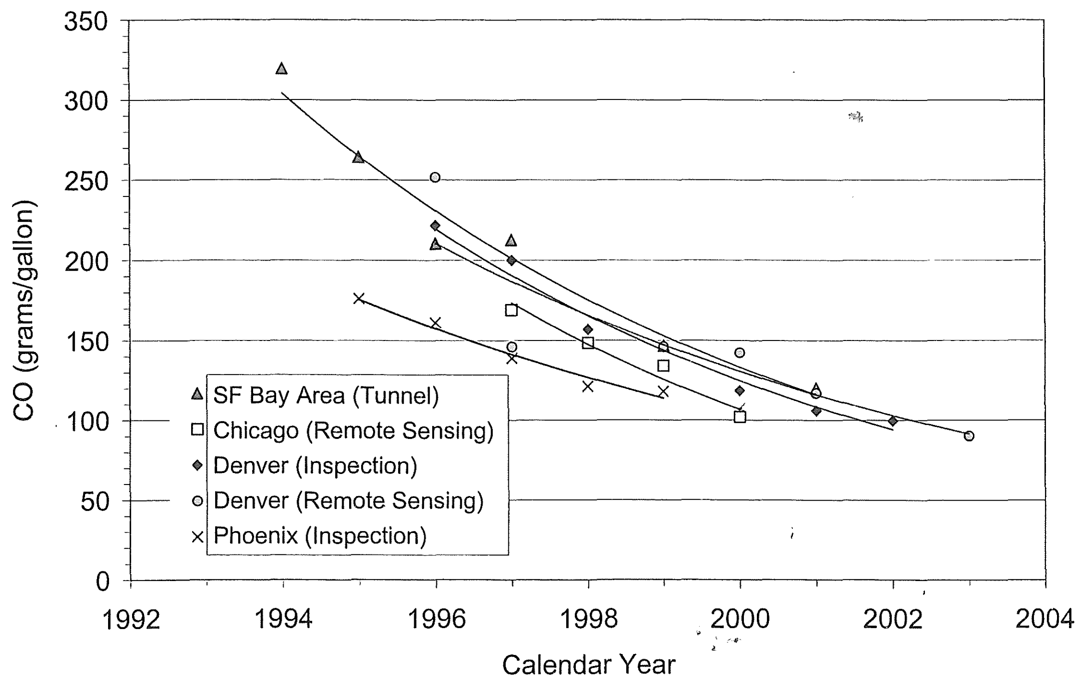
Ozone Trend



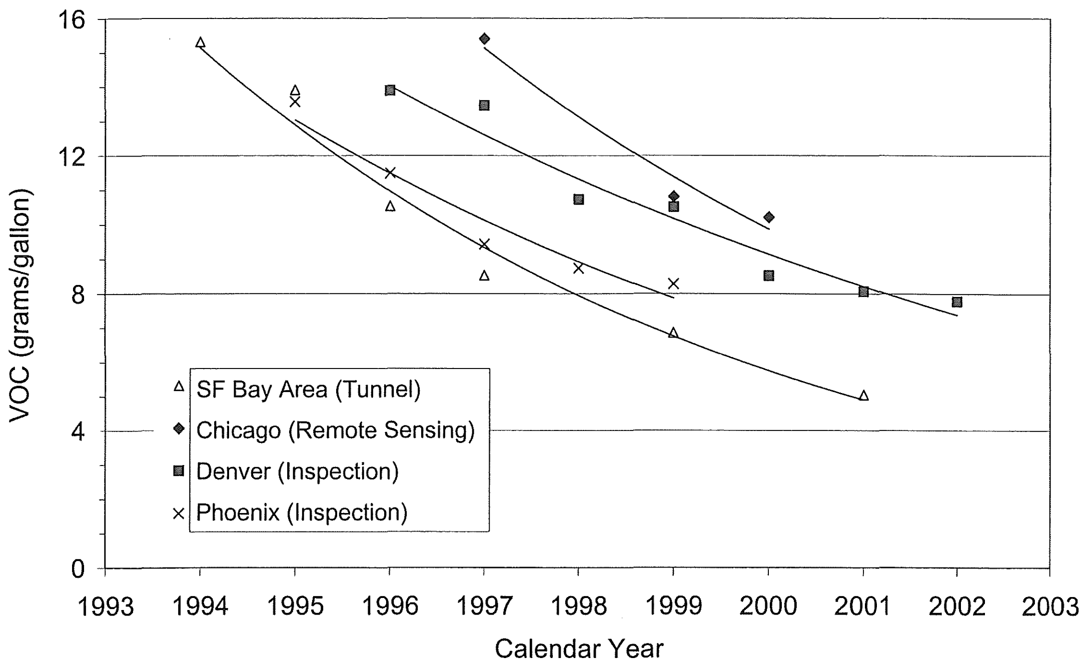
Notes: "Worst location" is Minnesota site with highest value in any given year. "Average" is average for all Minnesota sites operating in any given year. 8-hour standard is exceeded of any monitoring site's 4th-highest annual reading averages at least 0.085 ppm in any consecutive 3-year period. All data downloaded from EPA's AIRdata system.

* 8-hour standard is based on 4th-highest concentration each year (right graph), but this is roughly equivalent to averaging less than 4 exceedance days per year.

Automobile CO Emission Trend



Automobile VOC Emission Trend



Dr. Jones

TECHNICAL ISSUES OF INCREASED ETHANOL BLENDS

MINNESOTA STATE SENATE
ENVIRONMENTAL and NATURAL RESOURCES
COMMITTEE MEETING
2/2/2005

Bruce Jones Ph.D.
Director
Minnesota Center for Automotive Research (MnCAR)
Minnesota State University, Mankato

MINNESOTA CENTER FOR AUTOMOTIVE RESEARCH

- **To provide industry and government with technical expertise in automotive research and product development**
- **To provide undergraduate students the opportunity to become directly involved in comprehensive research projects**

MID RANGE ETHANOL STUDY

- **Conducted During 1998 and 1999**
- **Evaluate the Effects of 30% Ethanol and 70% Gasoline Blend on Unmodified Vehicles**
- **1 Year Study Focusing on:**
  - **Driveability**
  - **Material Compatibility / Durability**
  - **Fuel Economy**
  - **Emissions**

E30 VEHICLE POPULATION

- 1985 OLDSMOBILE CUTLASS CIERA 2.5L
- 1985 FORD ECONOLINE 150 4.9L
- 1990 CHEVROLET C1500 4.3L
- 1990 DODGE CARAVAN 3.3L
- 1991 CADILLAC SEDAN DEVILLE 4.9L
- 1992 FORD TAURUS 3.8L
- 1992 CHEVROLET K1500 5.7L
- 1992 GEO METRO 1.0L MANUAL
- 1994 BUICK REGAL 3.1L
- 1996 OLDSMOBILE ACHIEVA 3.1L
- 1997 CHEVROLET K3500 7.4L
- 1997 CHEVROLET K1500 5.7L
- 1997 FORD F-150 5.4L
- 1998 FORD F-250 5.4L
- 1998 DODGE CARAVAN 3.3L

DRIVEABILITY RESULTS and OBSERVATIONS

- Ambient Temperature Ranged from 0° F to 90° F
- Standardized Form Used to Record Any Abnormal Characteristics
- No Reports Of:
  - Cold Starting or Hard Starting Problems
  - Vapor Lock
  - Hesitation

MATERIAL COMPATABILITY

- Evaluated Through Use of Maintenance Log and Oil Analysis Testing
- Results
  - No Fuel System Component Failures
  - Oil Analysis Results Showed No Metal Particles Representing Accelerated Component Wear and No Indication Of Increased Oil Degradation
- Critical Area Needing Further Study

VOLUMETRIC FUEL ECONOMY

- Overall Fleet Average Fuel Economy Decreased 9.8%
- Volumetric Fuel Economy is Directly Related to the Energy Content of the Fuel.
  - There is Approximately 9.5% Less Energy in a Gallon of E30 Than Gasoline
  - Some Vehicles are More Sensitive Than Others

PROJECTED E20 FUEL ECONOMY

- E20 Blend has Approximately 3.3% Less Energy Than Current E10 Blend
- Expect a Slight Decrease in MPG Fuel Economy (1%-3%)
- However, the Reduction Is Not Necessarily the Same Magnitude as the Energy Density Difference

EMISSION CHARACTERISTICS

- No Significant Trends Identified Pointing to Increased Levels of HC, CO and NOx
- Some Vehicles Demonstrated Slightly Higher Levels While Some Lower
- All Emission Results Were Low

SUMMARY OF INCREASED ETHANOL CONTENT

- **FUEL ECONOMY – Vehicle Fuel Economy Will Follow the Same Trend as Energy Density.**
- **DRIVEABILITY – Closely Related to Fuel Volatility Which Can Be Easily Modified.**

SUMMARY OF INCREASED ETHANOL CONTENT

- **ENGINE CALIBRATION – Will Engines Run Properly?**
  - **Unmodified Vehicles (Closed-Loop Fuel Injection) Have Run on Blends Up To 50/50.**
- **Material Compatibility / Vehicle Warranty**
  - **Significant Issue for Manufacturers**
  - **Area Requiring Additional Research**

QUESTIONS

???????????????????????????
???????????????????????????
???????????????????????????
???????????????????????????

Dr. Jones

USE OF MID-RANGE ETHANOL/GASOLINE BLENDS IN UNMODIFIED PASSENGER CARS AND LIGHT DUTY TRUCKS

A one-year study focusing on the fuel economy, emission, driveability, and component compatibility characteristics of in-use light duty vehicles running on E30 and E10 was conducted at the Minnesota Center for Automotive Research (MnCAR) at Minnesota State University, Mankato. The purpose of the study was to test higher concentrations of ethanol in unmodified vehicles to determine not only if any problems existed. In addition the research was intended to identify any performance benefits that exist from using the fuel.

E10 fuel contains 90% gasoline and 10% ethanol by volume. In many regions of the country, especially the upper Midwest where the ethanol is produced from corn, 10% ethanol has been added to gasoline to help reduce the dependence on foreign oil. Ethanol is also an effective oxygenate which has been proven to help reduce vehicle tailpipe emissions. E30 contains 70% gasoline and 30% ethanol by volume.

Fifteen vehicles of various years, makes, and models were selected for the study. The owners of the vehicles agreed to participate in the study and were asked to only use E30 to fuel the vehicle. In addition they were asked to keep accurate records of the amount of fuel the vehicle consumed and to document any driveability problems they encountered and to report any component failure that occurred on the vehicle. During regular oil changes, samples of the oil were captured and sent to a lab for analysis.

Three times during the yearlong study the vehicles were brought to the MnCAR Labs for emission and fuel economy testing. The procedures used by the lab follow those set by the federal government for the certification of all vehicles sold in the U.S.

The testing involved putting the vehicle on a chassis dynamometer and driving it following a simulated trip of varying speeds. The driver follows a trace on a computer monitor that ensures the each time the vehicle is tested it follows the exact same path and under the same conditions. During each test measurements are made of the amount of Hydrocarbons, Carbon Monoxide, Oxides of Nitrogen, and Carbon Monoxide emitted from the tailpipe. Fuel economy is also calculated as part of the test. Several tests were made on each vehicle on both E10 and E30.

The results of the study revealed no driveability or material compatibility problems with any of the fifteen vehicles tested. While the volumetric fuel consumption, measured in miles per gallon, was generally worse when E30 was used as the fuel, in most cases the energy consumption, measured in BTUs per mile, was lower indicating the vehicle used the E30 more efficiently than E10. Tailpipe emission characteristics revealed extremely slight differences between E10 and E30. In some cases the E30 yielded statistically lower emissions and in some cases higher. This was due in part to the fact that all of the emissions were very low and in all cases well below federal standards.

For further questions regarding the study contact either Dr. Bruce E. Jones or Professor Kirk L. Ready at the Minnesota Center for Automotive Research, Minnesota State University, Mankato.

Phone - (507) 389-6383
bruce.jones@mankato.msus.edu
kirk.ready@mankato.msus.edu

Advanced_Technology

VEHICLES

DRIVING INNOVATION

Advanced_Technology VEHICLES>

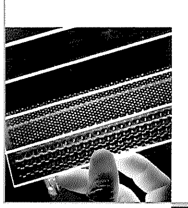
DRIVING INNOVATION

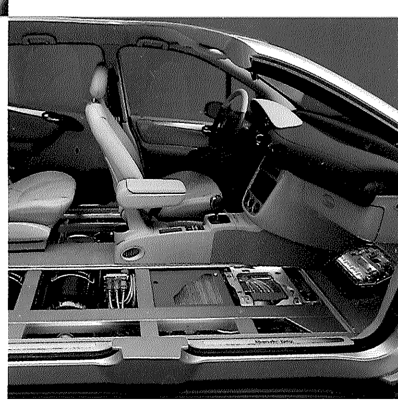
Advanced_Technology_VEHICLES

DRIVING INNOVATION

America's passion for automobiles has raced non-stop for more than a century, with no end in sight. **Cars. Pick-up trucks. SUVs. Minivans. They keep us mobile. They offer versatility. And whether it's elegant classics, this year's hot new models, or futuristic concept cars, they fuel our dreams and stoke our imagination.**

So what has kept this love affair so strong for so long? Throughout the automobile's history, few industries have worked harder to keep its promises to an eager public. Engaging designs. Higher performance. And the most important promise of all: ***creating exciting automobiles that are cleaner, safer, smarter, more reliable and more fuel efficient.***





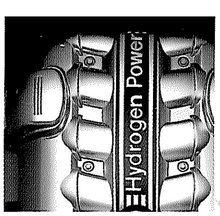
We've come a long way toward fulfilling these promises. The computers now used in every new car on the road are more powerful than those that helped the Apollo program reach the Moon. They handle everything from airbag safety systems and anti-lock brakes to GPS systems and emissions control. Today's vehicles are also better for the environment. They run 99 percent cleaner than their counterparts from the 1970s.

More good news is on the way. Automakers are working on multiple pathways for advanced technology vehicles that run virtually emission-free on the road to achieving zero emissions vehicles.

Drivers are learning a new vocabulary. Fuel cell. Hybrid electric. Clean diesel. Hydrogen. Alternative fuels. Cylinder deactivation. All of these terms are becoming familiar thanks to the billions of dollars that members of the Alliance of Automobile Manufacturers have invested in research, development, and deployment of advanced technology vehicles .

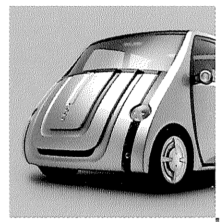
Bringing advanced technology to consumers in large numbers, however, remains a challenge. Consumers are accustomed to the comfort, safety, reliability and convenience of the internal combustion engine, and may hesitate to buy unfamiliar technology.

Cost is also a big issue. Any new technology is initially more expensive than the technology it has been designed to replace. Costs will remain high until consumers buy advanced technology vehicles in quantities large enough to bring costs down.



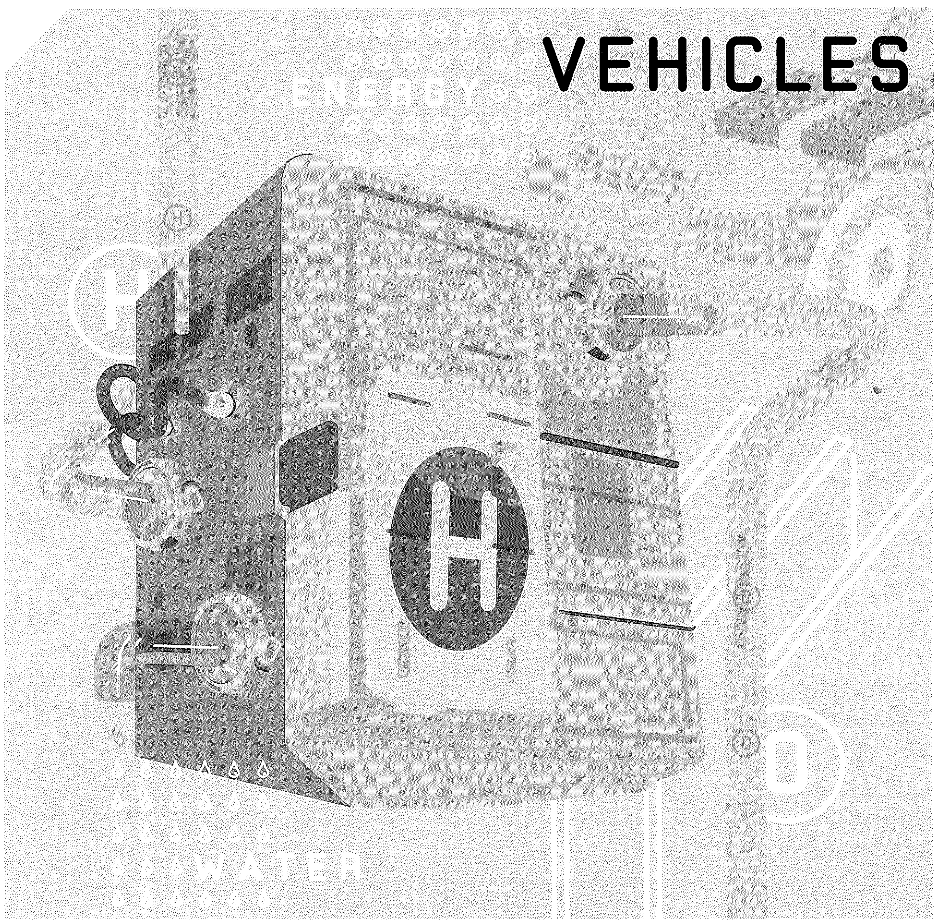
What's more, there are infrastructure challenges to overcome. Before fuel cells can go mainstream, the support network of hydrogen refueling stations must be in place. Given that there are 180,000 gas stations in the United States, conversion to a hydrogen energy supply is a formidable challenge.

Other advanced technology vehicles, such as advanced clean diesel, require ultra-clean, sulfur-free fuel. Flex-fuel vehicles running on natural gas or ethanol also have special fuel needs. Automakers are proud that there are more than 3 million alternative fuel vehicles on the road today, and that number will grow as the fueling infrastructure is put into place.



Overcoming these hurdles requires understanding. That's why we created this Advanced Technology Primer. You'll get a look at the exciting future ahead, and the advanced technology vehicles that are beginning to roll out.

Hydrogen_Powered VEHICLES



The environment's new best friend. Hydrogen powered vehicles offer vastly improved fuel efficiency over gasoline powered engines, and the only emission they produce is water vapor.

FC

Fuel Cell Vehicles.

1 *Hy-wire is so advanced that GM has more than 30 patents in progress covering business models, technologies, and manufacturing processes. The Hy-wire's fuel cell propulsion system is housed entirely in an 11-inch thick skateboard-like chassis. By-wire controls use electrical signals instead of mechanical links or hydraulics to control steering, acceleration and braking. Without an engine, steering column, or other conventional vehicle components, this concept provides unprecedented design freedom.*

1

2

3 *The DaimlerChrysler F-Cell passenger car is the latest in the company's line of fuel cell cars. DaimlerChrysler has also deployed fuel cell buses in Europe and Australia and fuel cell vans in Europe and the United States. The F-Cell's clean, quiet, efficient powertrain is housed in the car's floor, with no loss of passenger or cargo space.*

3

2 *The Toyota FCHV system features four 5,000-psi hydrogen fuel tanks. Hydrogen gas feeds into the fuel-cell stack where it is combined with oxygen. This chemical reaction forms water and generates a peak of 90 kW of electricity. The electricity from the fuel cell powers the 109-hp (194 lbs-ft of torque) electric motor and charges the vehicle's nickel-metal hydride batteries, which also feed power-on-demand to the electric motor. Water vapor is emitted through the vehicle's tailpipe.*

4 *The Volkswagen Bora HY.POWER's electric motor is rated at 75 kW (102 bhp) and obtains its power from a fuel cell that discharges only water vapor during operation. The HY.POWER prototype uses on-board hydrogen to create a hydrogen fuel cell. Fuel cells that use hydrogen offer zero emissions; fuel cells that use gas with reformers offer near-zero emissions.*

4

HYDROGEN ICE (INTERNAL COMBUSTION ENGINE) VEHICLES.

Not as well known in the United States, but possibly serving as another bridge technology to a hydrogen economy are hydrogen ICEs. The concept of using hydrogen in internal combustion engines offers several advantages: near-zero net emissions, maintaining the utility and flexibility of today's automobile and helping to promote a hydrogen fueling infrastructure.

Hydrogen emits water vapor when burned, and has the potential to be an environmentally friendly alternative. However, only a handful of public hydrogen refueling stations currently exist in the world, thereby limiting today's use of the technology. By using hydrogen ICEs as a bridge technology, perhaps cost per vehicle can be kept reasonable and help promote vehicle availability as well as the necessary infrastructure

5

5 The BMW 745h is a five-passenger luxury-performance sedan, powered by a 4.4 liter V8 engine, which runs on either liquid hydrogen or gasoline. The 750hL has a range of about 250 miles. With its dual fuel capacity, the 750hL can be switched to gasoline operation should it become necessary, eliminating any restrictions that might be imposed by range or hydrogen availability. The 745h also employs today's fuel cell technology to power the vehicle's electrical system. This source provides more power than a conventional battery, allowing, for example, the air conditioning or heating system to be operated with the engine off. Currently, BMW is further refining this hydrogen power plant and incorporating it into the new 7 Series sedans.

6

6 This technological concept vehicle powered by the Mazda RENESIS hydrogen rotary engine is now undergoing running tests. The hydrogen version of RENESIS is the latest example of the company's efforts to satisfy the demand for both environment-friendliness and exhilarating performance. By making the most of the unique rotary-engine technologies, Mazda was able to develop this powerplant as one proposal for alternative-energy vehicle technologies aimed at a future hydrogen-based society.

In addition to direct hydrogen injection into the intake chambers via two electronically-controlled injectors per rotor, the Mazda RX-8 Hydrogen RE features a dual-fuel system allowing one-touch switching between either hydrogen or gasoline, promoting the car's versatility as a hydrogen fuel infrastructure is developed.

7 A 2.3-liter, four-cylinder supercharged, intercooled hydrogen internal combustion engine, coupled with a hybrid electric transmission, propels the Ford Model U. It offers enhanced fuel economy —the equivalent of 45 miles per gallon and about 300 miles of range—plus near-zero regulated emissions and a 99-percent reduction in carbon dioxide. The powertrain also features Ford's advanced Modular Hybrid Transmission System, a way to simplify hybrid electric vehicle (HEV) technology in manufacturing, while contributing to significant fuel economy improvements.

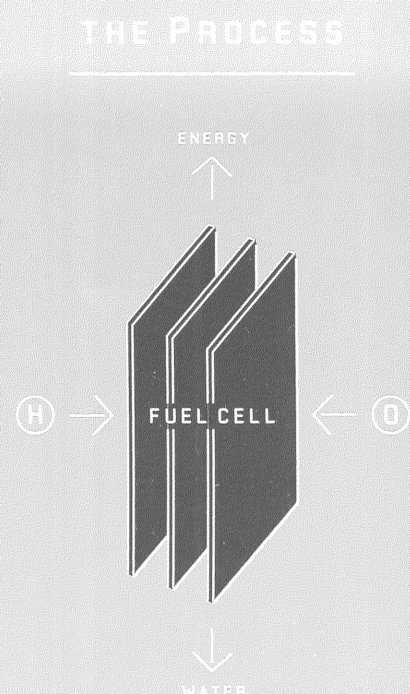
7

How Fuel Cells Work.

Fuel cells use hydrogen to produce continuous electric currents. They employ a process that chemically combines hydrogen and oxygen to produce electricity and water. Because each fuel cell produces less than one volt, they must be stacked in a row to produce enough voltage for the motor to meet your driving needs.

Electricity is produced when hydrogen is fed into one end of the fuel cell. There it meets a platinum anode that strips an electron from each hydrogen atom, producing an electric current and a stream of hydrogen ions. The electric current flows to the electric motor, supplying it with power. At the other end of the fuel cell, a platinum cathode brings together the stream of hydrogen ions coming from the platinum anode, the electric current returning from the electric motor, and oxygen. These three react to produce water.

You're probably wondering where we get the oxygen and hydrogen to supply the fuel cell. Oxygen is easy. It comes from the air, all you'll ever need. Hydrogen is trickier. We can produce it by reformulating a hydrogen-containing fuel — such as gasoline, methanol, or natural gas, or through electrolysis of water, heat or chemical reactions.



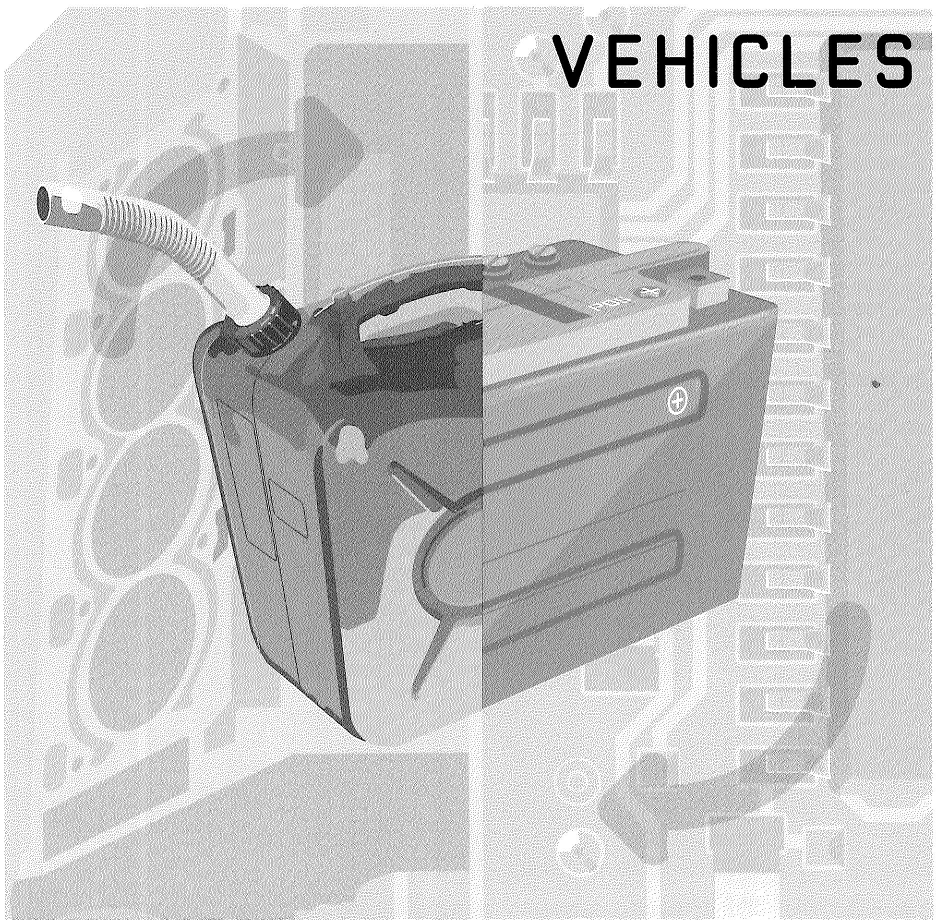
Fuel Cells are Flexible.

Fuel cells can be packaged into different shapes to fit into a vehicle's available space, so passenger room, cargo space and performance can be optimized.

The Challenge of Fuel Cells.

Like other emerging technologies, there are many challenges to overcome including storage, infrastructure, customer acceptance and cost. As mentioned, hydrogen cannot be stored as easily as gasoline; it must be compressed or kept at very cold temperatures. Automotive research continues to determine the best form of hydrogen to use as a fuel (i.e. solid, liquid, gaseous) and develop high pressure storage systems to increase vehicle range. Additional, non-automotive, research should occur concurrently to develop an emission free method of hydrogen generation, transportation and bulk storage and distribution. In early years, incentives to minimize cost discrepancies between technologies will considerably hasten customer acceptance of new technology. As has been seen in the past, as orders grow costs come down due to mass production.

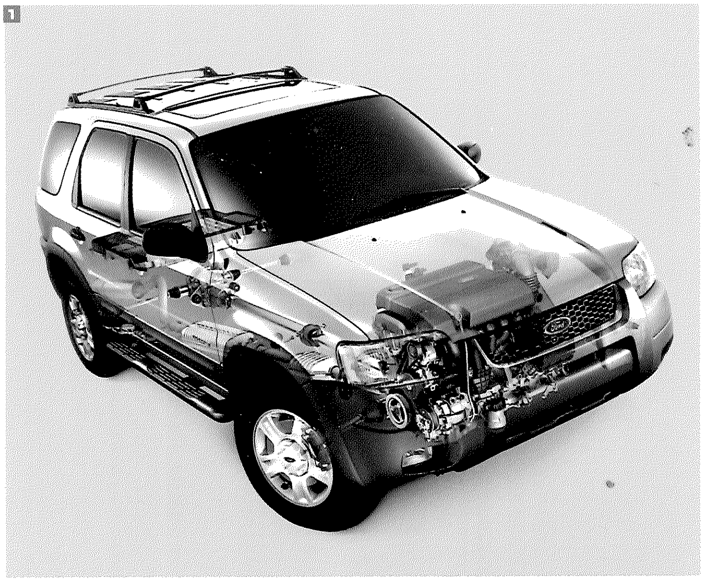
Hybrid_Electric VEHICLES



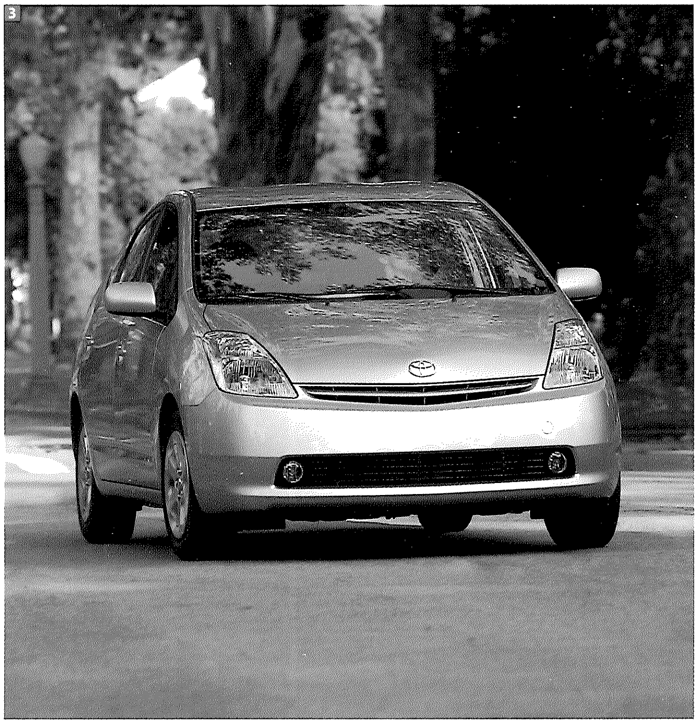
Here and Now. Hybrid Electric Vehicles (HEVs) provide quantum improvements in fuel efficiency and reduced carbon dioxide emissions while requiring no changes to the existing gasoline fuel infrastructure. HEVs are considered a bridge technology on the way to achieving an emission-free fuel cell vehicle.

Hybrid_Electric_Vehicles

1 The Ford Escape Hybrid will feature an electric drivetrain to augment its fuel-efficient, 4-cylinder gasoline engine. With regenerative braking and nearly instantaneous start-stop capability, the Escape Hybrid will be especially fuel-efficient in city traffic. The Escape Hybrid will deliver acceleration performance similar to an Escape equipped with a V-6 internal combustion engine. The Escape Hybrid will have a driving range of more than 500 miles on a single tank of gasoline. It will be available to consumers in late 2004.

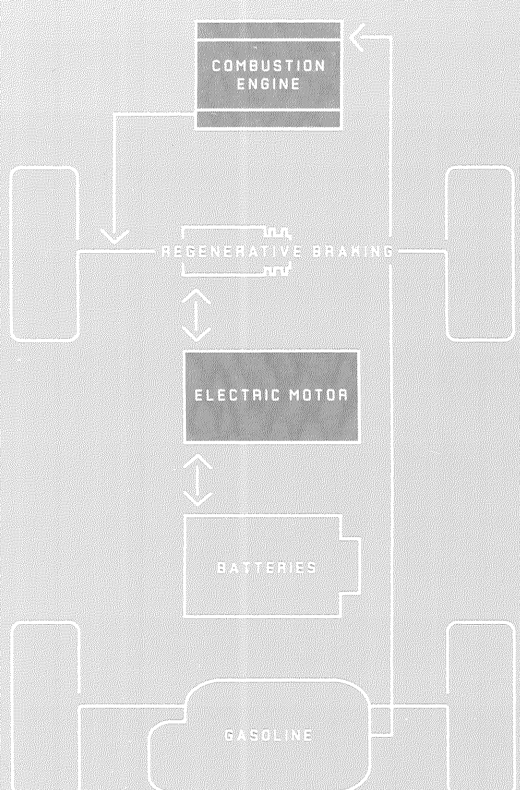


2 The Chevrolet Silverado and GMC Sierra Flywheel Alternator Starter Hybrid System allows uncompromised power and torque while increasing fuel economy by 10 to 12 percent. This flexible, functional "generator on wheels" has four 120-volt outlets and enough capacity to power tools on a work site or appliances at a campground. It will be available to consumers in 2004.



3 The new Prius is the first Toyota product to employ Toyota's Hybrid Synergy Drive, a third-generation, electric-gas hybrid powertrain technology. The new system produces more power from both the gasoline engine and the electric motor, giving the new Prius acceleration comparable to a 4-cylinder midsize car. The 2004 Prius can accelerate from 0-60 MPH in about 10 seconds and has a combined EPA mileage estimate of 55 MPG. Toyota will also introduce hybrid versions of its Highlander and Lexus RX SUVs in fall 2004.

4 The diesel electric hybrid Dodge Ram heavy-duty pickup has an integrated starter-generator powertrain that produces up to 10 percent better fuel efficiency and enhanced performance on the road. Off the road, the powertrain converts to a clean generator to provide electric power in remote sites.



What are Hybrid Electric Vehicles?

Hybrid Electric Vehicles (HEVs) are an evolutionary new powertrain that utilizes a battery powered electric motor, a gasoline internal combustion engine, and a concept know as regenerative braking. To optimize performance, emissions, and fuel efficiency a computer is used to manage the energy from these three systems. The computer senses the driving style and then directs energy from either the battery system or the gasoline engine to the most appropriate drive train component, an electric motor or a drive shaft. Utilizing these hybrid technologies, an up to 25 percent improvement in fuel economy over conventional automobiles can be achieved.

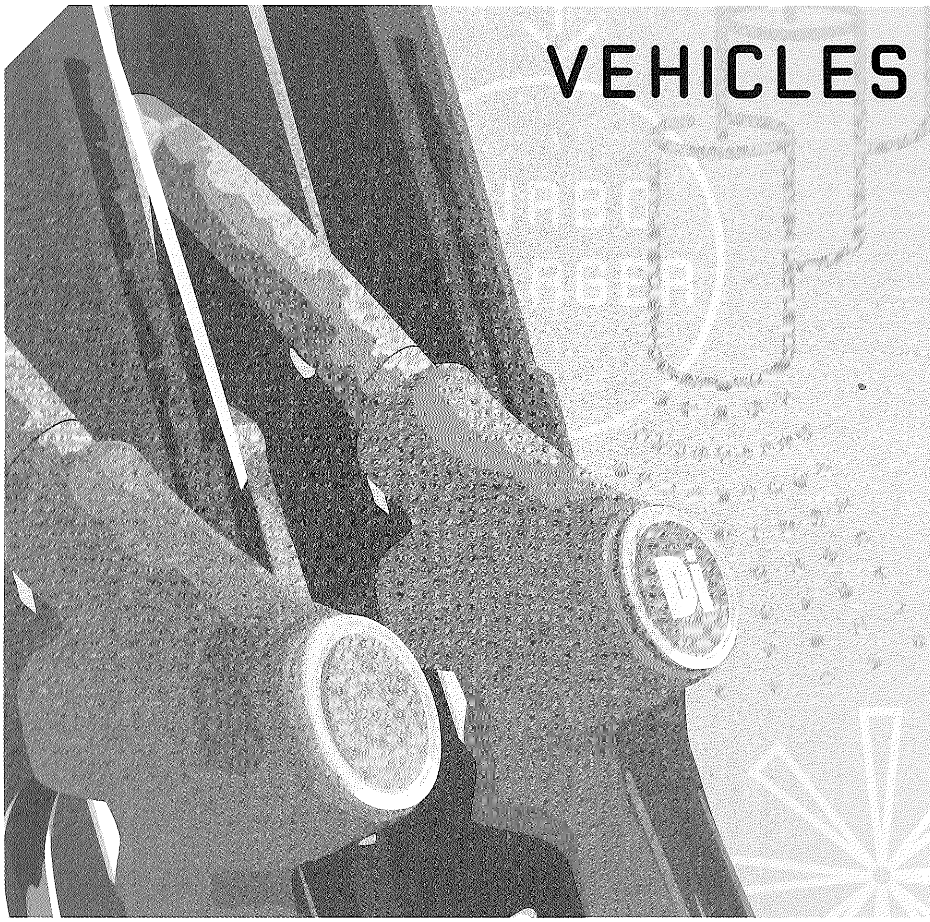
How do HEVs stack up against pure battery electric vehicles?

Easy. They have greater range because of the added energy from the fuel-powered engine and regenerative braking. Pure battery-electric cars require regular charging.

For now, cost remains an important issue for HEVs. Because hybrid electrics use two separate powertrains, they cost more than internal combustion engine-only cars. To narrow the cost gap between typical cars and hybrids, the IRS has approved a one-time tax deduction for hybrid buyers.

Clean_Diesel

VEHICLES



Technological advances have resulted in clean diesel automobiles that offer greater fuel economy, while delivering the performance and durability the consumers demand. Diesel has become "clean diesel" through advanced engine and emission control technologies in conjunction with ultra-low sulfur fuel.

Clean_Diesel_Vehicles

4 The Ford Mondeo TDCi TDCi power is easy on your pocket—and the environment. Common-rail technology delivers outstanding fuel economy, low running costs and reduced emissions. It uses a two-stage injection—a pilot and a main injection. Because the fuel is injected in smaller bursts, the resulting smooth, progressive fuel combustion is quieter and more efficient. Which means you spend more time on the road, enjoying the engine's power and refinement, and less time stopping to fill up.

1

4

1 In Europe, the 2003 BMW 530d gets 30.2 MPG, versus 23.8 MPG for its gasoline counterpart. 2 The 2003 BMW 740d sedan gets 28.9 MPG, compared to 24.4 MPG for the gasoline version.

2

5

3 The Jeep Liberty diesel will be powered by a 2.8-liter common rail turbo-diesel engine and will be available with two- or four-wheel drive. The diesel-powered Liberty will have up to 30 percent better fuel efficiency compared with a comparable gasoline-powered Liberty.

3

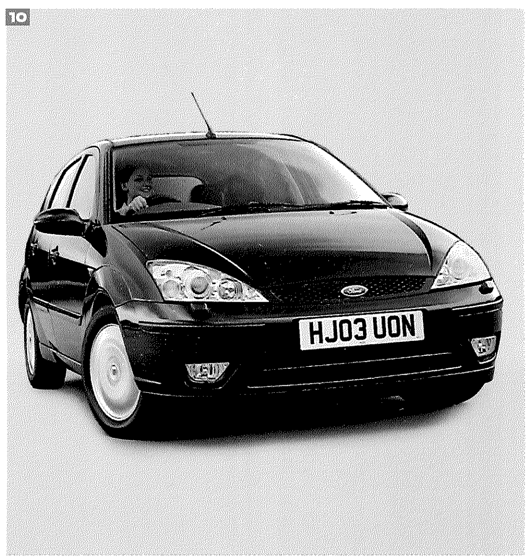
5 The Mercedes E320 CDi (Common-rail Direct Injection) uses an electronic fuel injection system that once was considered technically impossible on diesel engines. CDi works by electronically maintaining a precise, constant high level of fuel pressure (according to speed and throttle) to each of the engine's six injectors. Fuel injection using the CDi system softens diesel "power pulses" resulting in smoother, quieter, and more powerful performance.

6 *The stylish and versatile Volkswagen Passat TDi gets 28 MPG, about a 32% increase over its gasoline counterpart, which gets 21.4 MPG.*

9 *The Audi A8 TDi, a premium sports sedan, gets 29 MPG, compared to 20 MPG for the gasoline version.*

7 *Saab 9-5 with a 3.0L V-6 common rail turbo diesel engine is 25 percent more efficient than the 4-cylinder gas counterpart.*

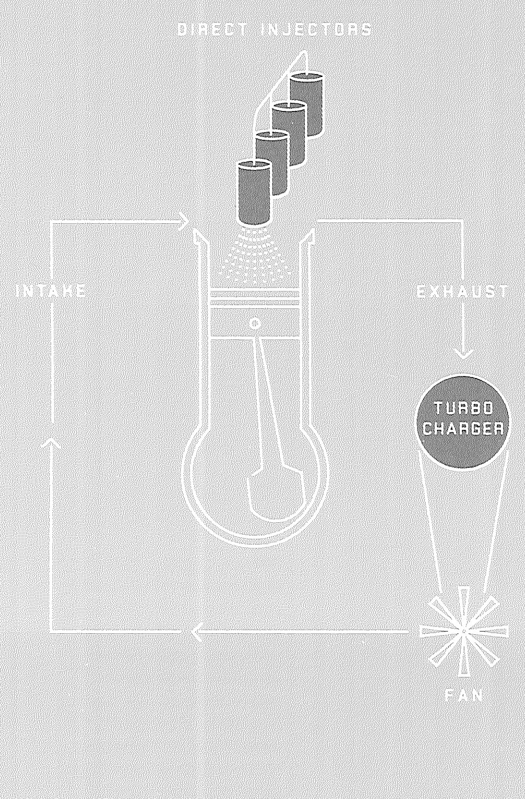
8 *Chevrolet Silverado's latest generation Duramax V-8 diesel engine delivers more horsepower and torque, while reducing NOx emissions by nearly 50 percent.*



10 *The Ford Focus TDCi. Refined, responsive and quiet. These are the hallmarks of the new generation. Ford diesel found in the widely popular Focus—the Duratorq TDCi. With its advanced engine refinement and superb performance, you could mistake it for a gasoline engine.*

The new Duratorq TDCi engine leads the way in fuel economy and running costs. On average you will find a TDCi engine will travel 13 miles further per gallon than a gasoline engine of comparable size. In addition, the engine is incredibly quiet. Using new Noise Reduction Technology called 'accelerometer pilot control' (APC), the TDCi engine 'listens' to itself to monitor noise levels. Finally, Ford's Duratorq TDCi engine emits almost 20% less carbon dioxide than a gasoline engine.

THE PROCESS



A NEW GENERATION.

Compared to their gasoline counterparts, the emerging new generation of clean diesel vehicles will offer greater fuel economy while delivering better performance. Around the world, consumers are favoring advanced diesel technology. Clean diesel powers 40% of Europe's new light duty motor vehicles.

Today's diesel vehicles run more cleanly, thanks to new fuel injection, combustion and exhaust after-treatment technologies. And the auto industry is working now to introduce technologies that will allow diesel automobiles to meet the Environmental Protection Agency's latest emissions regulations. A key factor in determining the success of these aftertreatment technologies was the EPA's 2001 decision to require dramatic sulfur reductions in diesel fuel. This decision was critical for the sale of clean diesel vehicles in the U.S.

THE IMPROVEMENTS ARE DRAMATIC.

Clean diesel vehicles are more fuel-efficient than gasoline-powered vehicles, especially in stop-and-go city driving. On average, clean diesel vehicles achieve 20-40% better fuel economy than their gasoline-powered counterparts.

Clean diesel vehicles cost significantly more to produce than conventional vehicles. As with all low volume, new technology vehicles, Congress can help get clean, highly fuel-efficient vehicles on the road more quickly in greater volumes by providing consumer tax incentives for clean diesel automobiles.

Alternative_Fuel VEHICLES

Finding substitutes for oil. Finding cleaner, more efficient alternatives to gasoline for internal combustion engines has been one of the long-term goals of the automobile industry. While the research continues, several beneficial fuels are in use today—and are gaining popularity.

B

Biofuels.

Biodiesel is produced through a process in which organically derived oils are combined with alcohol *(ethanol or methanol)* in the presence of a catalyst to form an ethyl or methyl ester.

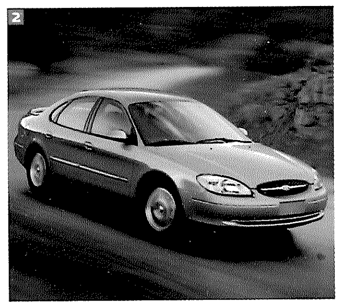
Ethanol can be produced from a variety of renewable resources, such as corn and grain. Researchers are investigating how to make ethanol from the wood and plant cellulose found in biomass, which could make ethanol economically viable as well as ecologically sound.

1 VW Golf TDi uses SunFuel,® a new synthetic diesel fuel produced from biomass. It is completely free of sulfur and aromatic compounds and is CO_2-neutral, as its combustion in the engine only releases the CO_2 back into the atmosphere that a plant absorbed while it grew.

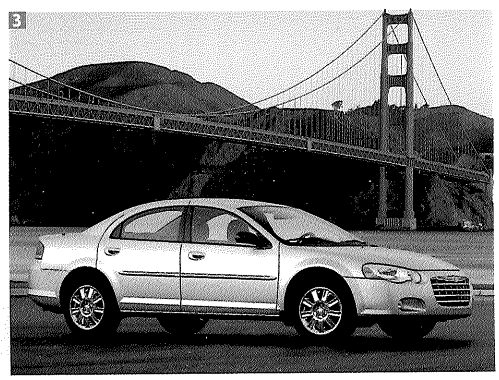
Ford makes a 2 Taurus that runs on ethanol. The vehicles are called Flexible Fuel Vehicles (FFVs) because they can run on any combination of gas and up to 85 percent ethanol in the same tank. Ford introduced FFV products with the Taurus in 1993.

1

2

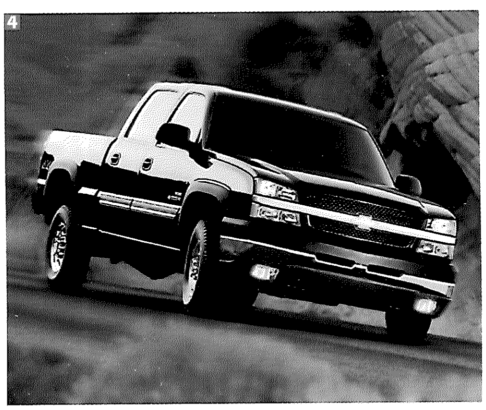


3



3 DaimlerChrysler has sold more than one million flexible fuel vehicles, capable of running on gasoline or E85 fuel comprising 85 percent renewable ethanol. The 2004 Dodge Ram 1500 truck with 4.7-Liter V-8 engine and Dodge Stratus and Chrysler Sebring sedans equipped with 2.4-liter engines are the latest of the company's vehicles to come equipped with E85 capability.

4



4 There are currently more than 3 million E85 vehicles on American roads — more than 1 million of them produced by GM. All GM full size SUVs equipped with the Vortec 5300 engine are E85-capable, including the Chevrolet Tahoe and Suburban and the GMC Yukon and Yukon XL. The Chevrolet Silverado and GMC Sierra full size pickups also are available with E85 capability. E85 alternative fuel composed of 85 percent ethanol and 15 percent gasoline used in Flexible Fuel Vehicles helps reduce greenhouse gas emissions and enhance energy security by providing an alternative to petroleum fuels.

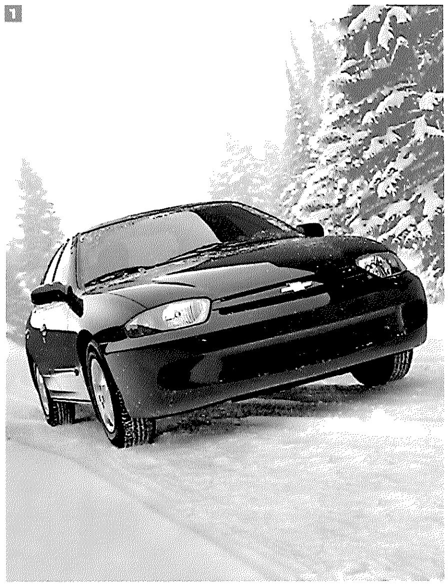
NG

Natural Gas.

Lighter than air, natural gas is found in deposits 3,000 to 15,000 feet below the surface of the earth. It is available in two forms: compressed or liquefied (CNG and LNG). CNG vehicles have a very good safety record, partly because of strict design regulations.

This attractive alternative, however, does face challenges. Natural gas vehicles need about four times the fuel tank volume to provide the same driving range as gasoline vehicles. As a result, natural gas vehicles require a potential trade off: less driving range or compromised cargo capacity. What's more, natural gas fuel tanks, as well as the required fittings, add significant cost to these vehicles.

1



1 *The Chevrolet Cavalier is a Bifuel CNG sedan with a 2.2-liter engine; four-speed automatic transmission. It has a 6.2-gge CNG capacity at 3,600 psi, with 14.3-gallon gasoline tank for total driving range of up to 411 miles.*

P

Propane.

Propane is the popular name for liquefied petroleum gas, or LPG. This liquid mixture consists of at least 90 percent propane, butane and higher hydrocarbons; the balance is ethane and propylene. Propane is a by-product of natural gas processing or petroleum refining.

The driving range for LPG-powered vehicles is a little less than that of comparable gasoline-powered vehicles. But because LPG is stored as a liquid, its driving range is greater than that of CNG-powered vehicles. Power, acceleration, payload, and cruise speed are all comparable with those you would get using a gasoline engine.

1 *Ford offers a bi-fuel propane, F-150, light-duty pick-up truck that runs on propane or gasoline.*

1

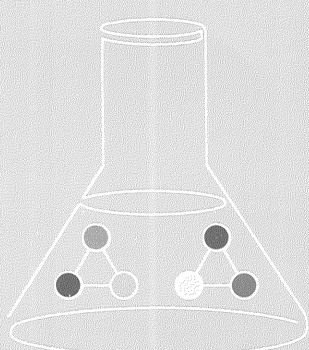
Alternative Fuel Vehicles.

More than 3 million alternative fuel vehicles are now on the road. But increasing that number remains a challenge. Fueling these vehicles requires new infrastructure, with special pumps for such fuels as ethanol and natural gas. Consumers may be reluctant to buy alternative fuel vehicles unless they are assured that fueling these vehicles will be as convenient as stopping at the local gas station. And gas station owners may be reluctant to build additional special pumps unless they are assured that there will be enough vehicles on the road to make them worthwhile.

Biofuels.

Biofuels such as ethanol made from starch and biodiesel made from vegetable oil already clean our air and help support our rural economies. Biodiesel is produced through a process in which organically derived oils are combined with alcohol (ethanol or methanol) in the presence of a catalyst to form an ethyl or methyl ester.

The Alternatives

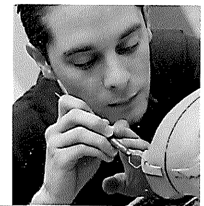


Natural Gas.

As a fuel alternative, natural gas is, well, a natural. It burns cleanly, reducing carbon monoxide emissions by 65-90 percent, and almost eliminates particle emissions entirely. Natural gas is also widely available. The U.S. and Canada have significant deposits. Plus, the U.S. has gas distribution pipelines and several refueling stations.

Propane.

Propane is the most accessible of the liquid and gaseous alternative fuels. More than 10,000 publicly accessible fueling stations operate throughout the United States, where there are more than 350,000 on- and off-road propane-powered vehicles. About 3.5 million of these vehicles are in use worldwide. This shouldn't be a surprise. Propane has been used as a transportation fuel around the world for more than 60 years.

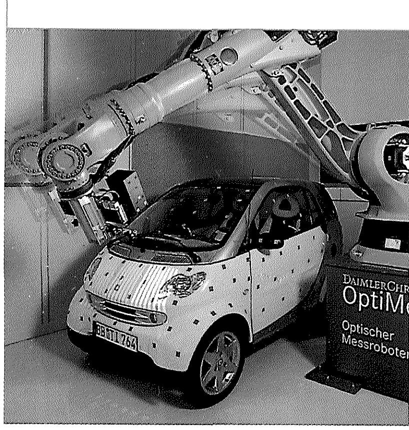


Advanced_Technology_VEHICLES

Advanced technology vehicles of all kinds offer hope and promise for the future. **Whether it's achieving greater fuel economy or reducing the reliance on oil as a primary fuel source, automakers remain committed to populating America's roadways with the latest innovative vehicle technologies.**

Congress can help get clean, highly fuel-efficient vehicles on the road more quickly in greater volumes by providing consumer tax incentives.

The challenge remains getting consumers to accept these new cars and light trucks in large numbers. But as consumers learn more about advanced technology vehicles, their acceptance grows. That's why we've created this document: ***to educate consumers and encourage them to look at an advanced technology vehicle when they start looking for their next new car.***



Want to know more?

Visit the Alliance at *www.autoalliance.org*.

DRIVING INNOVATION

AUTO ALLIANCE

1401 Eye Street, NW
Suite 900
Washington, DC 20005

www.autoalliance.org

Mn Corn Growers Assn

E20 for Minnesota

Clearing the air about ethanol

What's been said...

- **It takes more energy to produce ethanol than ethanol makes available.**

The facts are...
Although this claim may have been true 20 years ago, increases in efficiency for both corn and ethanol production make this claim laughable. The fact is, a recent study calculates that ethanol has a positive net energy balance of 1.67. Contrast this to the negative net energy balance of gasoline of .81.

More information: See chart on page 5 of "The 2001 Net Energy Balance of Corn-Ethanol"

What's been said...

- **E20 use in Minnesota won't make a dent in this country's dependence on foreign oil.**

The fact is...
It is certain that demand for foreign oil will continue—but there are two compelling reasons to move to E20. First, we have the resources to make ethanol right here, and Minnesota's economy does benefit from replacing gasoline with ethanol. And second, any reduction in the portion of our fuel that comes from unfriendly or at best unstable areas of the world is significant.

What's been said...

- **Increasing ethanol to 20 percent in fuel will require significant design changes to vehicles.**

The fact is...
It can be done and, in fact is being done in other countries already. Why not here?

What's been said...

- **Motorists will see a costly reduction in fuel efficiency.**

The fact is...
Mileage is a compound issue, impacted by vehicle design, driving conditions and fuel type. There may be tradeoffs, but the net impact on our states economy and reduced greenhouse gas emissions cannot be ignored.

What's been said...

- **Minnesota should achieve 20 percent ethanol use through increased use of E85.**

The fact is...
A good idea—one that should be aggressively pursued. But why stop there? Brazil made a policy decision to fuel its cars with the fuel is has. Minnesota should do the same.

What's been said...

- **The type of fuel we use in our vehicles shouldn't be government-mandated.**

The fact is...
The type of fuel we put in our tanks is already mandated. If this is really a concern, let's remove the current mandate that requires 90% of our gasoline to be "gasoline". The American people, through our elected officials, have been enacting "mandates" in all segments of society for 200 years. Our speed limits are mandated, as are all kinds of equipment mandates on our vehicles.

What's been said...

- **Ethanol requires expensive government subsidies.**

The fact is...
Ethanol is attempting to compete with gasoline, which has been heavily subsidized by the U.S. government for much of the past century. Ethanol producer payments pale in comparison to what is being spent year after year on government aid to the oil industry. And domestic ethanol production does not require the use of our military to ensure an uninterrupted source of energy.

More information: Read "Oil Slickers"

MINNESOTA DEPARTMENT OF AGRICULTURE

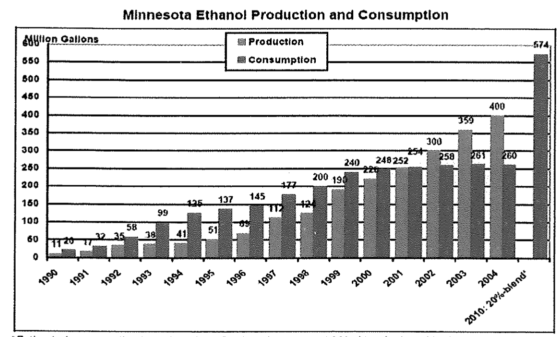
ECONOMIC IMPACT OF THE ETHANOL INDUSTRY IN MINNESOTA

ethanol Fuel For Clean Air

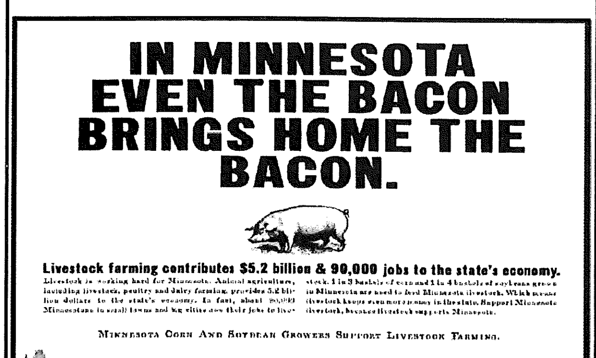
Agricultural Marketing Services Division
Minnesota Department of Agriculture

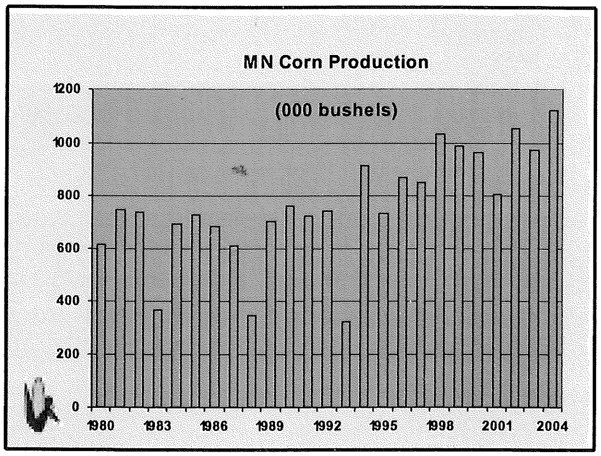
May 2003

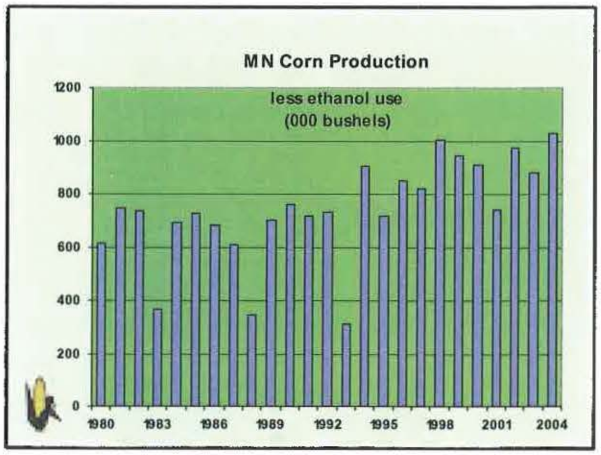
www.mda.state.mn.us



*Estimated consumption based on Gov. Pawlenty's proposed 20%-blend ethanol by 2010.
Source: AMS, MDA







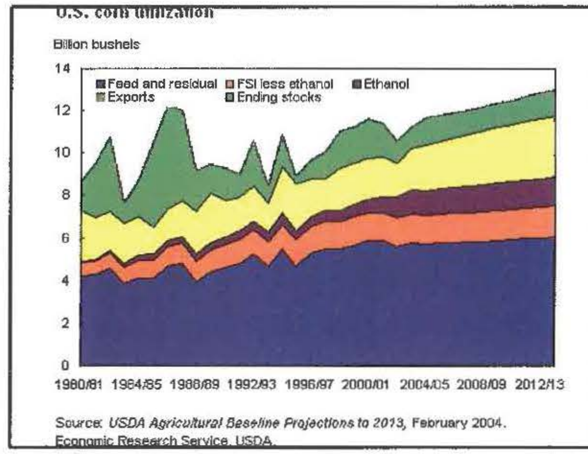
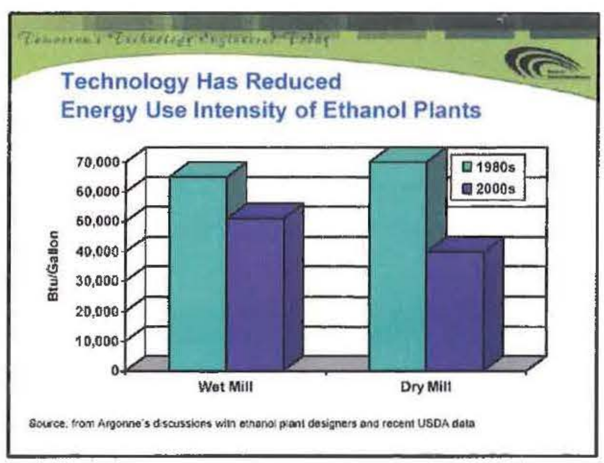
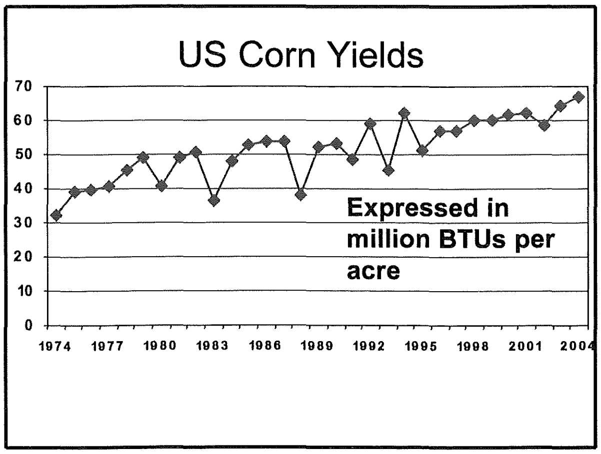
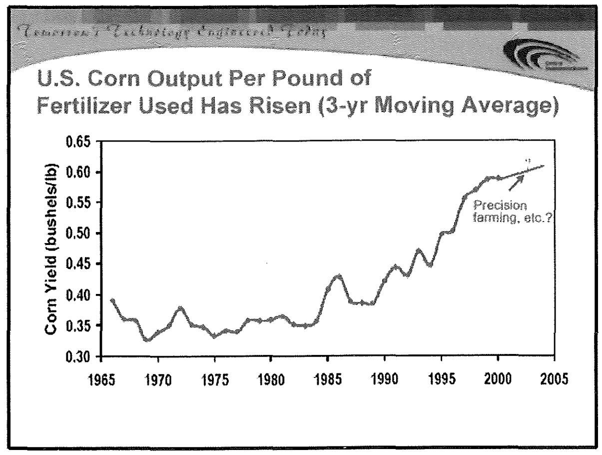


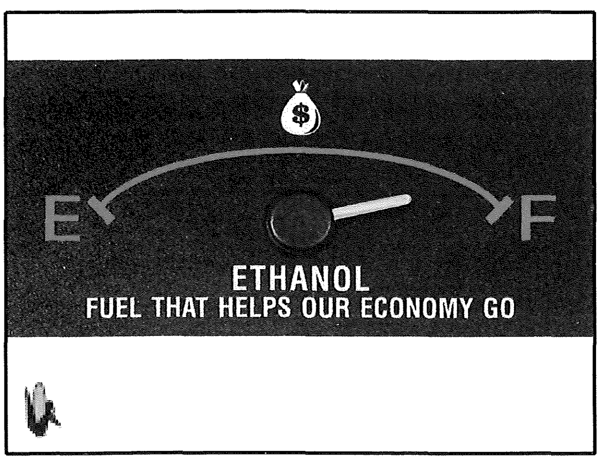
Table 4--Energy use and net energy value per gallon with coproduct energy credits, 2001

Production process	Milling process Dry	Milling process Wet	Weigted average
	Btu per gallon		
Corn production	12457	12244	12350
Corn transport	1411	1387	1399
Ethanol conversion	27799	33503	30586
ethanol distribution	1467	1467	1467
Total energy used	43134	48601	45802
Net energy value	33196	27729	30528
Energy ratio	1.77	1.57	1.67




US Corn Yields
Expressed in million BTUs per acre
70
60
50
40
30
20
10
0
1974 1977 1980 1983 1986 1989 1992 1995 1998 2001 2004


U.S. Corn Output Per Pound of Fertilizer Used Has Risen (3-yr Moving Average)
Corn Yield (bushels/lb)
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
1965 1970 1975 1980 1985 1990 1995 2000 2005
Precision farming, etc.?


E
F
ETHANOL
FUEL THAT HELPS OUR ECONOMY GO

MINNESOTA DEPARTMENT OF AGRICULTURE
FROM THE FARM TO YOUR FAMILY

ECONOMIC IMPACT OF THE ETHANOL INDUSTRY IN MINNESOTA

ethanol
Fuel For Clean Air

Agricultural Marketing Services Division
Minnesota Department of Agriculture

May 2003

www.mda.state.mn.us

INDEX

INDEX *(continued)*

MINNESOTA ETHANOL STATISTICS

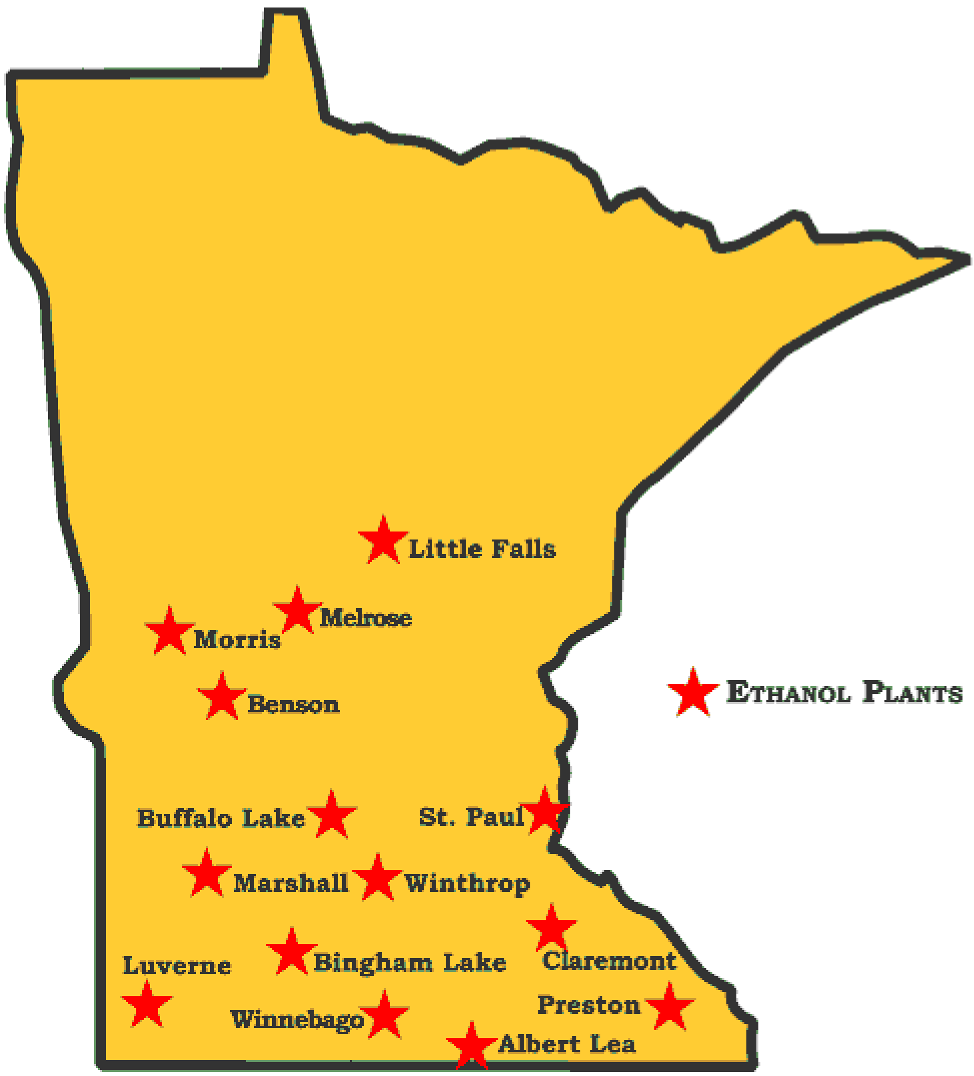
	2002	1990
Ethanol Production	300 million gallons	11 million gallons
Ethanol Consumption	240 million gallons	20 million gallons
Net Ethanol export/import	60 million gallons exported	9 million gallons imported
Ethanol Plants	14 plants	5 plants
Ethanol Producer Payment	$34 million	$2 million
Economic Impact		
• Output impact	$588 million	$29 million
• Employment impact	2,564 jobs	166 jobs
Corn Production	1,052 million bushels	763 million bushels
Rank in Corn Production	No. 3	No. 4
Total Corn processing	138 million bushels	34 million bushels
Corn Processed for Ethanol	120 million bushels	4.4 million bushels
Corn Prices	$2.15/bushel	$2.17/bushel
Ethanol Prices	$1.14/gallon	$1.33/gallon

ethanol

Fuel For Clean Air

ETHANOL PLANTS IN MINNESOTA

UPDATED FEBRUARY 2002



"It is a goal of the state that ethanol production plants in the state attain a total annual production level of 240,000,000 gallons."

–Minnesota Statute § 41A.09, Subd. 1a.

The Minnesota Ethanol Program

A. Background:

The 20-cent ethanol producer payment legislation (1986) initially provided the security required by lenders to invest in small farmer-owned ethanol facilities. In addition to opposition from the petroleum industry, bankers were concerned that these plants could not compete in the market with large agribusiness processors. At the time, most ethanol production occurred in large mills outside the state. Minnesota corn prices were among the lowest in the country, which was an advantage for local processing.

Although these ventures have been successful to date, margins have been squeezed by periods of record high corn prices and low ethanol prices. It is hoped that ten years of payments will allow plants to retire debt, increase efficiency and develop new products and markets so they can survive the competition and price fluctuations in agricultural and petroleum markets. Unique aspects of the ethanol industry made these incentive payments necessary, but the ethanol industry is projected to contribute over $350 million in increased economic activities in the state.

Since low commodity prices are common, these new corn plants may represent a new strategy for the long-range profitability of farmers and farm communities. Vertical integration from the bottom up could allow farmers to participate in the more profitable end of agriculture. Promoting farmer investments in the processing and marketing of other crop or livestock enterprises may not require the high level of state funding as did ethanol. It is hoped that such initiatives can allow farmers to make it on their own and reduce the need for funding of farm financial crisis measures.

B. The main components of the Minnesota Ethanol Program are:

1. An oxygenated fuel statute that requires state-wide oxy-fuel (ethanol blend) use;
2. The 20 cent per-gallon ethanol producer incentive provides payment for ethanol produced;

Plus
- ♦ $550 million was spent for total corn/ethanol plant construction and startup costs;
- ♦ $370 million in private sector financing was contingent on local equity capital;
- ♦ $180 million in local equity capital was raised by over 8,000 farmer and business members;
- ♦ $200 million worth of corn is committed for processing annually by local farmers.

C. The goals of the program include:

1. To build a new market for the state's largest crop (corn);
2. To develop corn processing/ethanol production facilities in Minnesota;
3. To increase the number of New Generation Farmer Coops (NGCs). These businesses were designed to provide farmer-members greater direct cash return for their crops;
4. To replace 10 percent of imported petroleum we use for gasoline (estimated at $100 million annual savings); and
5. To help the Twin Cities Area meet U.S. EPA standards for carbon monoxide.

D. Results to date:

1. 120 million bushels of corn (12 percent of Minnesota's crop) is made into ethanol and livestock feed (2002);
2. Minnesota's 14 plants produced 300 million gallons of ethanol in 2002;
3. Twelve of Minnesota's 14 ethanol plants were organized as NGCs**;
4. Nearly 10% of our gasoline is being replaced by ethanol each year; and
5. The Twin Cities Area met EPA's carbon monoxide standard and has achieved "attainment" status (the continued use of ethanol is required to keep emissions low).

The Minnesota Ethanol Program

Ethanol Production vs. Ethanol Use

Year	Production *mm=million*	Estimated Consumption	% MN Ethanol Produced Here
1986	1 mm gal.	25 mm gal.	4% of total
1994	41 mm gal.	125 mm gal.	33% of total
2002	300 mm gal.	240+ mm gal.	100% of total

Ethanol Plants & Capacities in 2002

City & (plant name)	Capacity *gallons/year*	mm. bushel corn/year	Start-up year	New Generation Co-op** Members
Marshall (ADM)	40 million	15	1988	(Public Corp)
Morris (DENCO)	20 million	7.4	1991	345
Winnebago (Corn Plus)	40 million	14.8	1994	750
Winthrop (Heartland)	32 million	12.9	1995	692
Benson* (CVEC)	20 million	7.4	1996	850
Claremont (Al-Corn)	30 million	10.3	1996	354
Bingham Lake (Ethanol2000)	30 million	10.3	1997	241
Buffalo Lake (MN Energy)	18 million	5.5	1997	325
Melrose (Dairy Proteins)	3 million	Cheese whey	1986	(Regional Co-op)
Preston (Pro-Corn)	40 million	14.8	1998	159
Luverne (Corn-er Stone)	20 million	7.4	1998	197
Little Falls (CMEC)	20 million	7.4	1999	820
Albert Lea (Exol/Agri Resources)	40 million	14.8	1999	496
St. Paul (Gopher State Ethanol)	13 million	4.8	1999	(Public Corp)
Current TOTAL	***366 mm gal.***	***133 mm bu.***		**5,229**

Processing corn products instead of exporting corn as raw commodity adds value to each bushel of corn. In addition to fuel ethanol, corn plants also produce high-protein livestock feeds plus other products such as corn sweeteners, starch, and carbon dioxide.

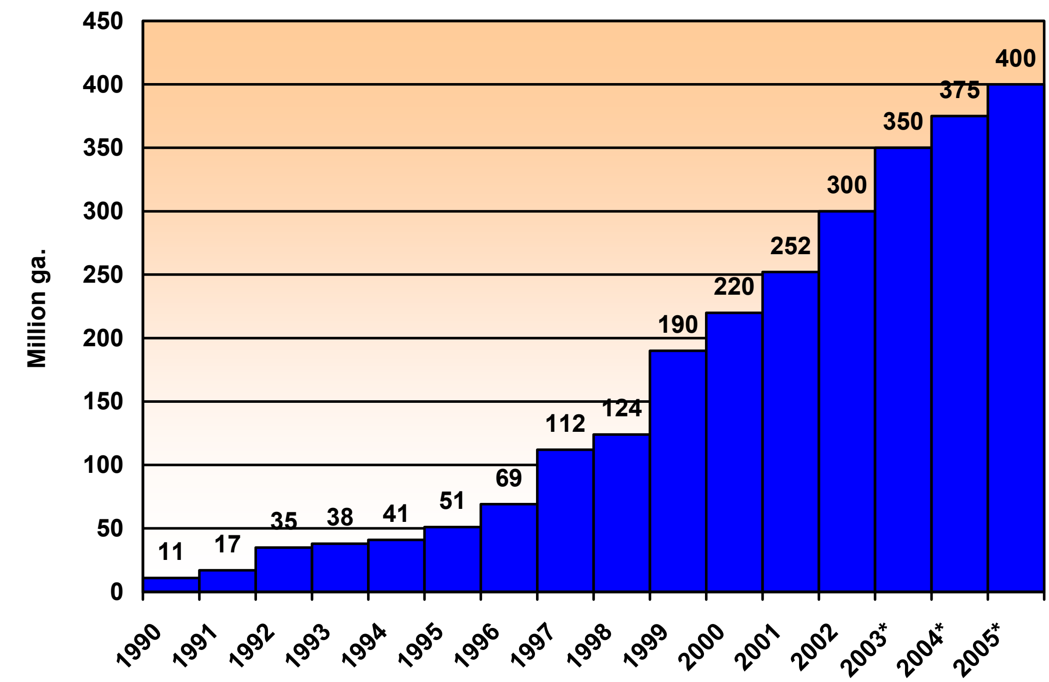
* Benson plant will add 20 million gallons by 2004.

** Plants organized as New Generation Farmer Co-ops (NGC) may be combined with, converted to or organized as limited liability companies or partnerships that are generally designed to:

1) be built by farmers and local businessmen to process member crops;
2) return more cash to farmers than conventional markets would provide;
3) be controlled by farmer/local board members so that member profits remain a top priority; and
4) create a stable source of local jobs and economic development.

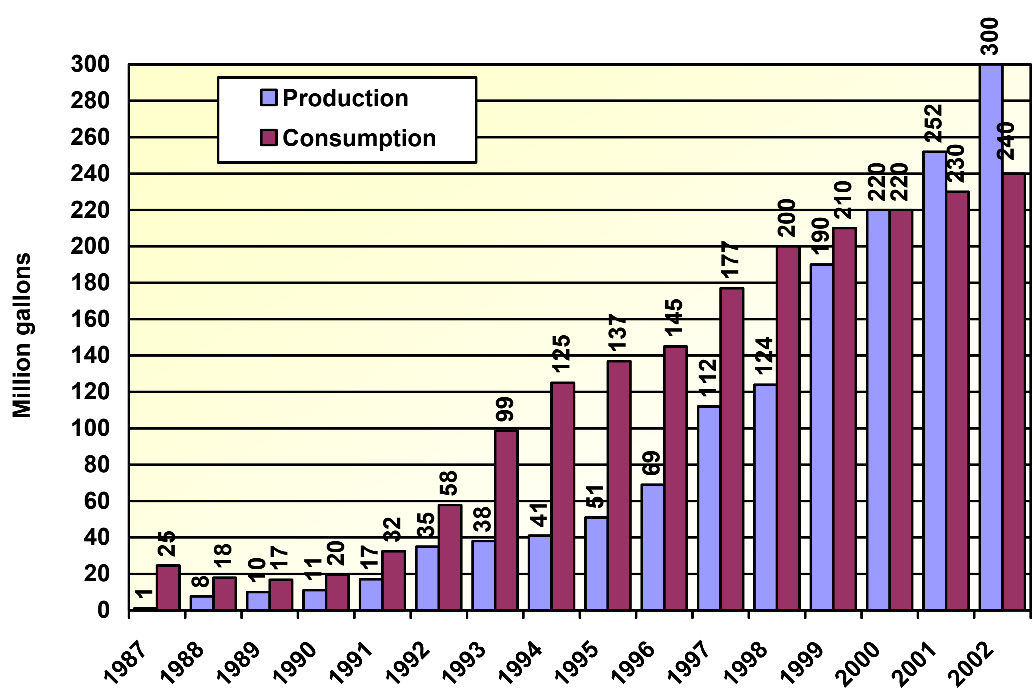
Minnesota Ethanol Production Trend

Fiscal Year: July 1-June 30



2003-2005: Projected.

Minnesota Ethanol Production and Consumption



LEGISLATIVE SUMMARY OF THE MINNESOTA ETHANOL PROGRAM

Minnesota passed legislation in ***1980*** offering a 4 cent per gallon pump tax credit for 10 percent ethanol/gasoline blends. The credit was available to marketers responsible for paying the gasoline tax to the state.

By ***1986,*** 40 percent of the state's gasoline was blended with 10 percent ethanol, but little ethanol was produced in Minnesota. Legislation reduced the pump tax credit to 2 cents and initiated a 20 cent per gallon cash incentive payment for ethanol produced in the state.

In ***1987***, legislation provided $100,000 annually to conduct an ethanol promotion program in the Minnesota Department of Agriculture. The Minnesota Ethanol Commission was established to promote the production and use of ethanol in Minnesota. Activities included: 1) production of educational documents and events; 2) troubleshooting consumer and industry concerns about ethanol fuels; 3) helping develop farmer-owned ethanol production facilities; and 4) providing information to policymakers, the public and the media.

In ***1989,*** the mandatory pump labeling requirement for ethanol blends was discontinued in favor of voluntary labeling that was more consistent with other gasoline components.

In ***1992,*** a minimum 2.7 percent oxygen content requirement for gasoline was made effective year-round in the Twin Cities in '95 and then statewide in 1997. A federal program previously required 2.7 percent oxygen in the Twin Cities during the winter months.

In ***1993,*** funding was provided for $500,000 loans to assist ethanol plant developers.

In ***1994*** 1) a phase out of the pump tax credit was made to coincide with phasing in the statewide oxygen requirement; 2) a stock loan program would participate with banks loaning money to qualified farmers who wished to buy stock in ethanol plants.

In ***1995***, a statutory goal to develop 220 million gallons of Minnesota ethanol production was established.

In ***1998***, the production goal was increased to 240 million gallons of ethanol, and approval for the 15th ethanol plant was authorized.

In ***2000***, the content of non-ethanol oxygenates such as MTBE in gasoline was restricted to 1/3 percent.

In ***2003***, 14 plants remain with a total annual production capacity of over 360 million gallons. Current state statute requires that the payments be reduced from 20 cents to 19 cents per gallon effective July 1, 2004. Of the $70 million allotted for 2002-03 biennial ethanol producer payments, $20 million was un-allotted by the governor. Three separate bills considered during the 2003 session include reducing the ethanol producer payment from 20 cents per gallon to 15, 13 and 10 cents per gallon respectively. The outcome of the session was not known at the time this summary was written.

ECONOMIC IMPACT OF THE ETHANOL INDUSTRY IN MINNESOTA

This economic impact analysis was conducted with the IMPLAN program (an input-output economic modeling system) to examine the ethanol industry in Minnesota. It estimates the ethanol industry's total economic contribution, or "multiplier effect", to the state economy, especially the ***output*** and ***employment*** impacts.

The economic impacts are measured to include the direct, indirect, and induced impacts. Direct impact represents the effect of the ethanol industry's production output. Indirect impact represents the effect on all other economic sectors due to purchases by the ethanol industry to generate the afore-mentioned output. Induced impact represents the effect on all economic sectors due to the expenditures of new income generated by the direct and indirect impacts. Total impact is the sum of direct, indirect and induced impacts.

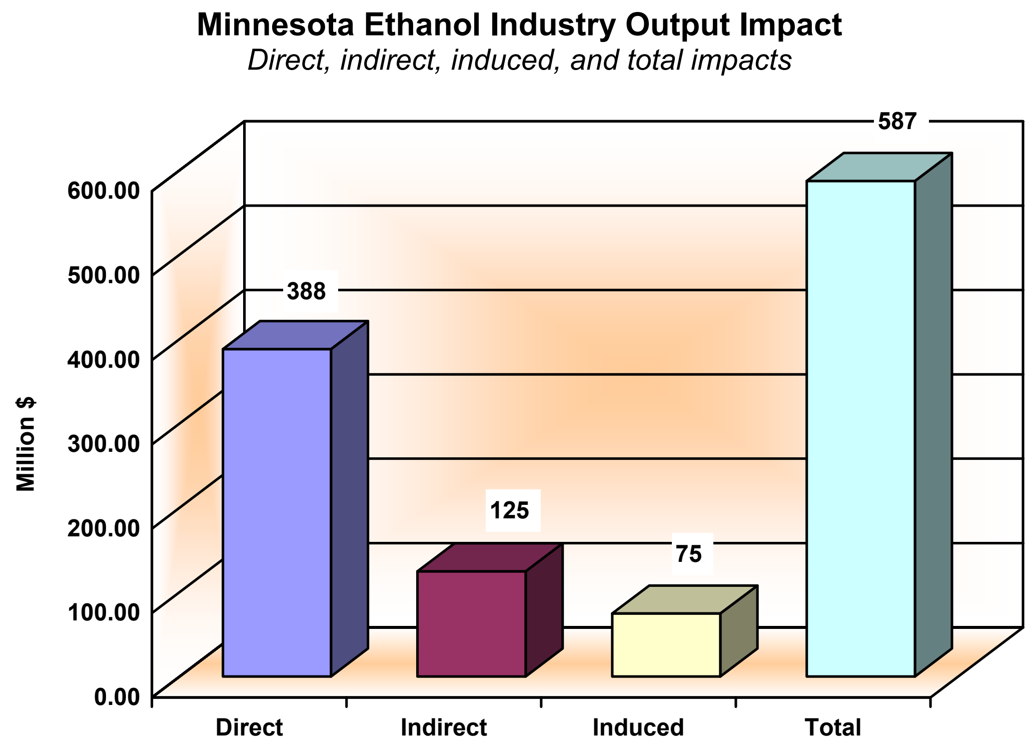
IMPACT ANALYSIS

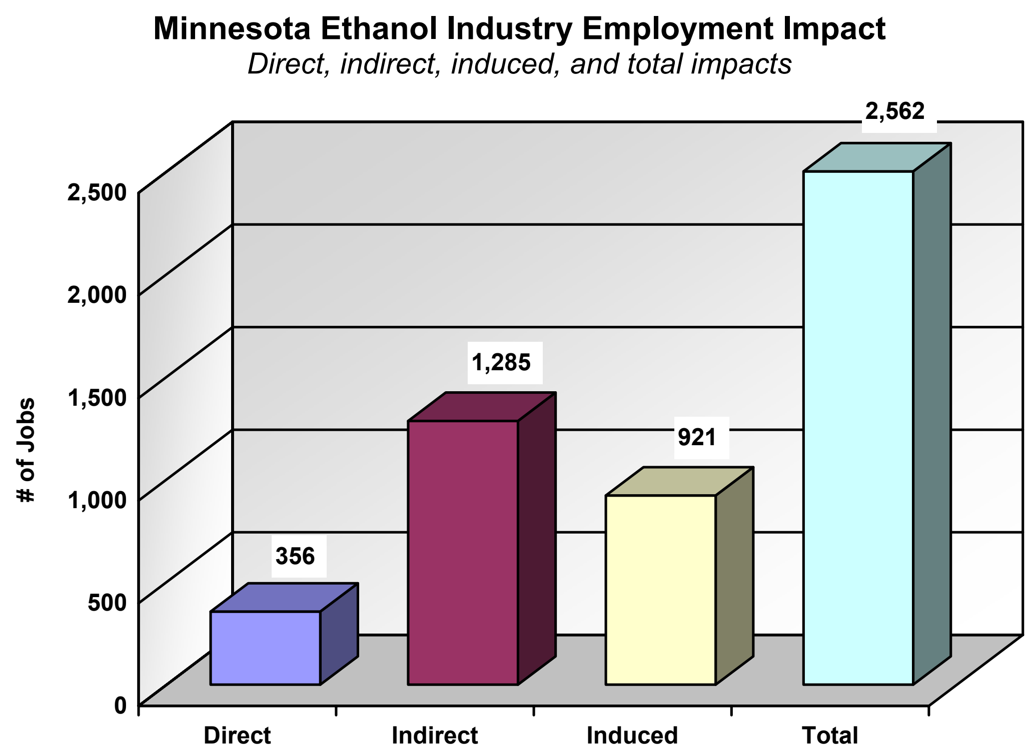
	Impact
Ethanol production	300 million gallons
Corn use	120 million bushels
Ethanol sales	$308 million
Corn feed sales (DDG & gluten feed/meal)	$80 million
Ethanol industry's total value of output	$388 million
Ethanol producer payment	$34 million

Total Economic Impacts

("Multiplier impact" in all economic sectors)

Total economic impact	
- Output impact	$587 million
- Employment impact	2,562 jobs


Minnesota Ethanol Industry Output Impact
Direct, indirect, induced, and total impacts
Million $
600.00
500.00
400.00
300.00
200.00
100.00
0.00
388
125
75
587
Direct
Indirect
Induced
Total


Minnesota Ethanol Industry Employment Impact
Direct, indirect, induced, and total impacts
# of Jobs
2,500
2,000
1,500
1,000
500
0
356
1,285
921
2,562
Direct
Indirect
Induced
Total

IMPACT ANALYSIS (continued)

Economic Impact by Sector

OUTPUT IMPACT BY SECTOR

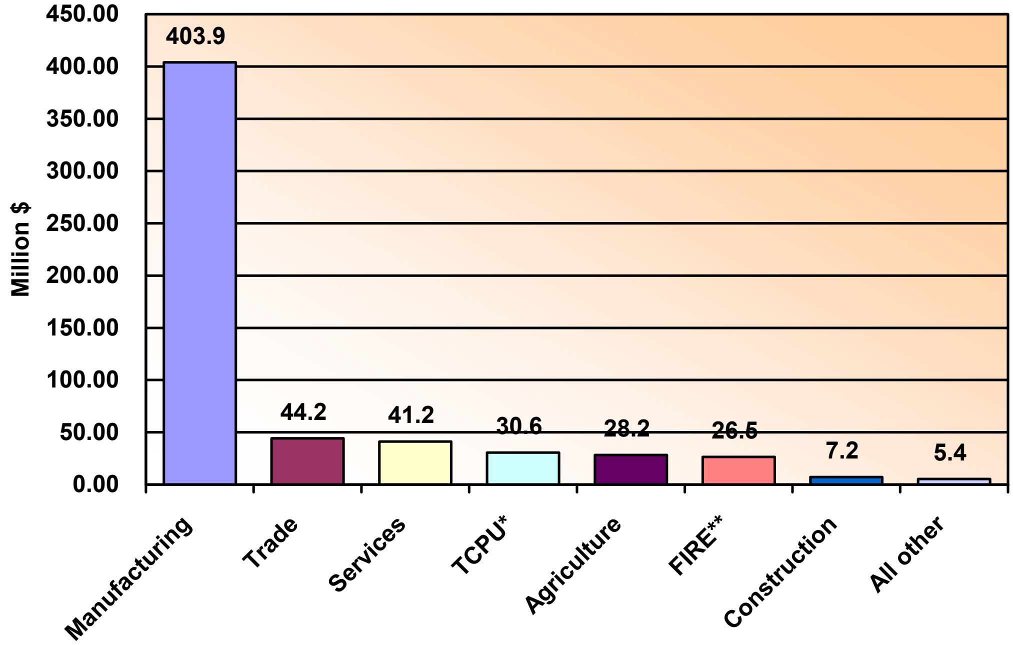
Sector	Impacts
1. Manufacturing	$404 million
2. Wholesale & retail trade	$44 million
3. Service	$41 million
4. Transportation, communication, and and public utilities	$31 million
5. Agriculture	$28 million
6. Finance, insurance, and real estate	$27 million
7. Construction	$7 million
8. All other	$5 million
Total	**$587 million**

EMPLOYMENT IMPACT BY SECTOR

Sector	Impacts
1. Service	674 jobs
2. Wholesale & retail trade	550 jobs
3. Agriculture	484 jobs
4. Manufacturing	419 jobs
5. Transportation, communication, and public utilities	163 jobs
6. Finance, insurance, and real estate	136 jobs
7. Construction	94 jobs
8. All other	42 jobs
Total	**2,562 jobs**

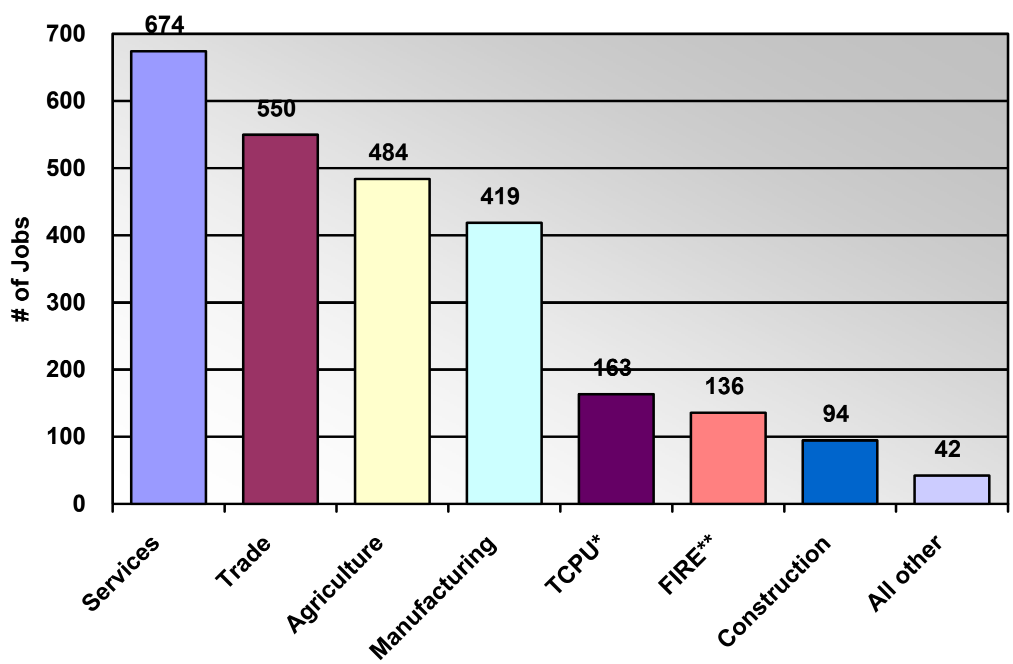
Minnesota Ethanol Industry Output Impact by Sector

Total output impact: $587 million



Minnesota Ethanol Industry Employment Impact by Sector

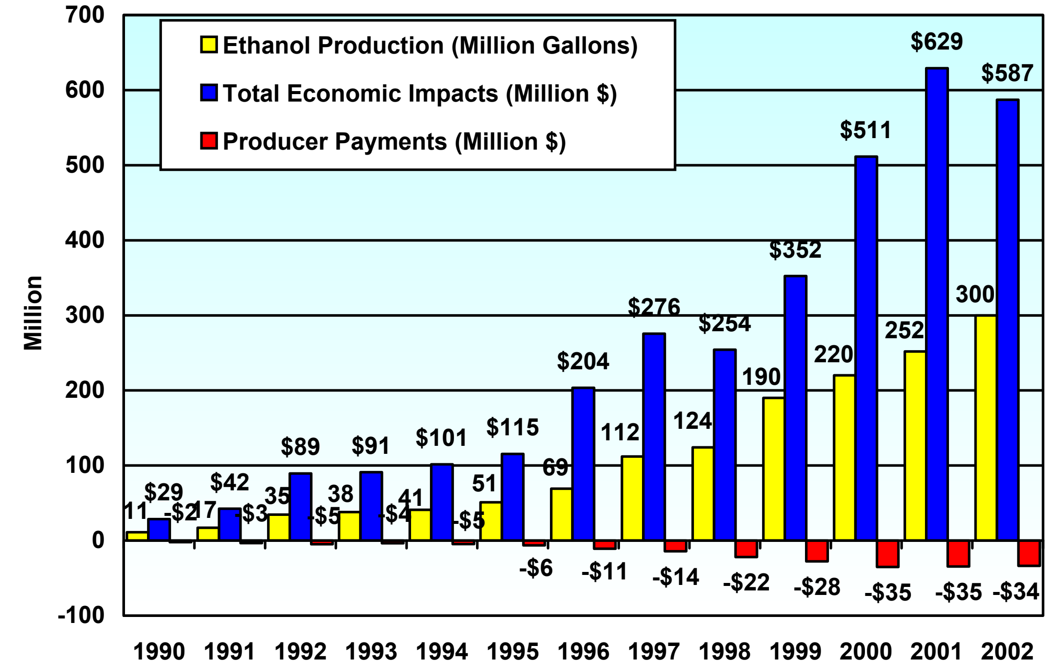
Total employment impact: 2,562 jobs



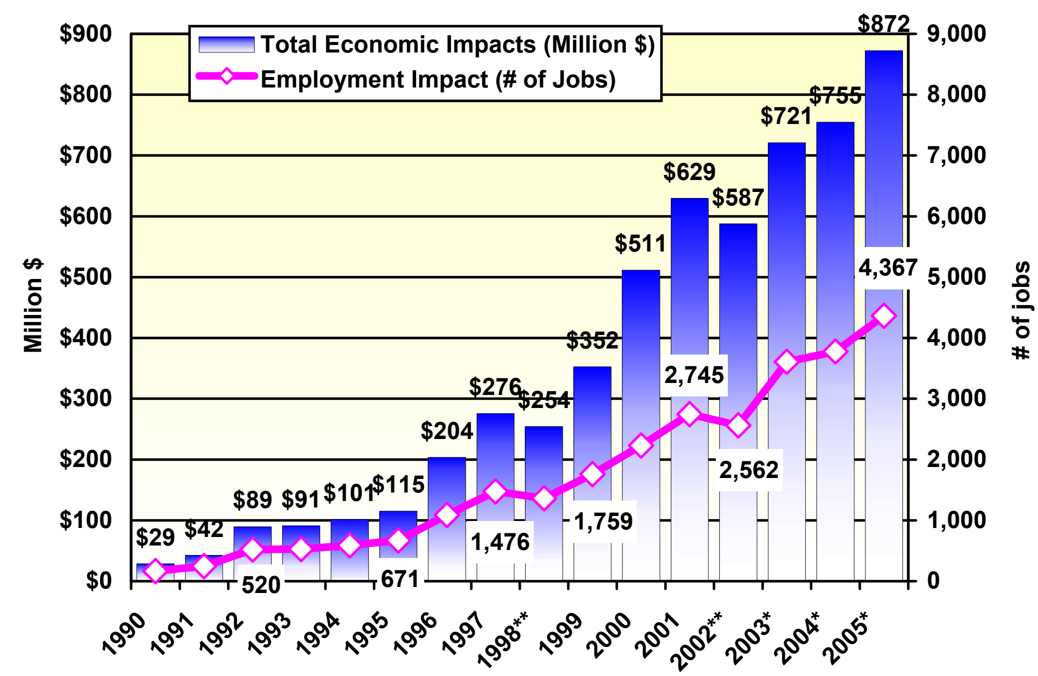
**TCPU: Transportation, communication, and public utilities.*
***FIRE: Finance, insurance, and real estate.*

Minnesota Ethanol:
Production, Producer Payments, and Economic Impacts

(Fiscal Year: July 1-June 30)



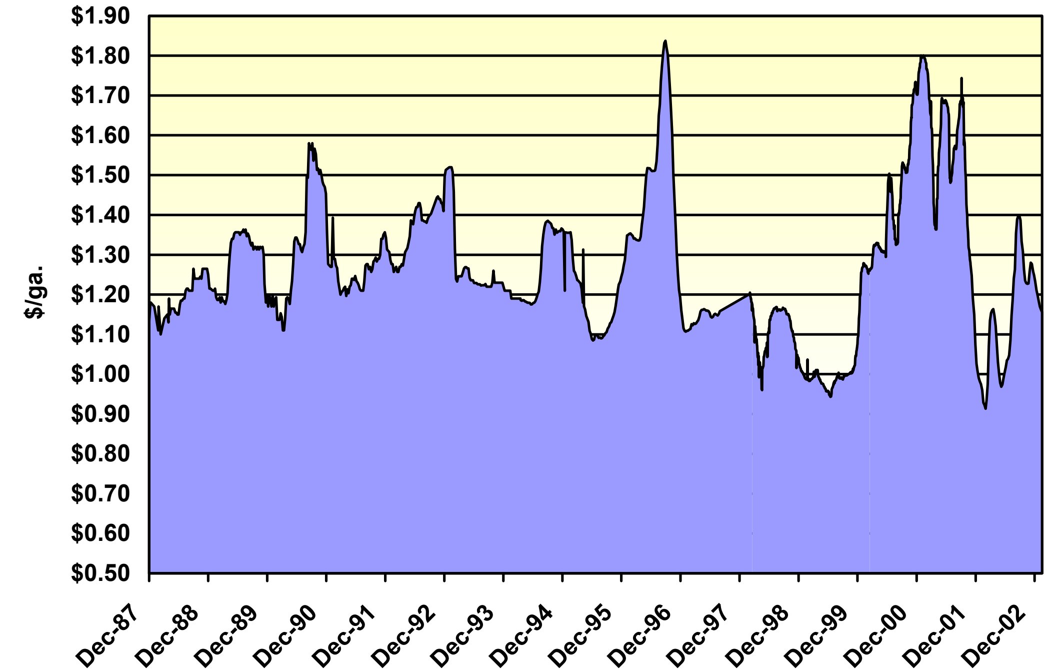
Minnesota Ethanol:
Total Economic Impact & Employment Impact



*2003-2005: Projected.
**In 1998 and 2002, ethanol prices declined.

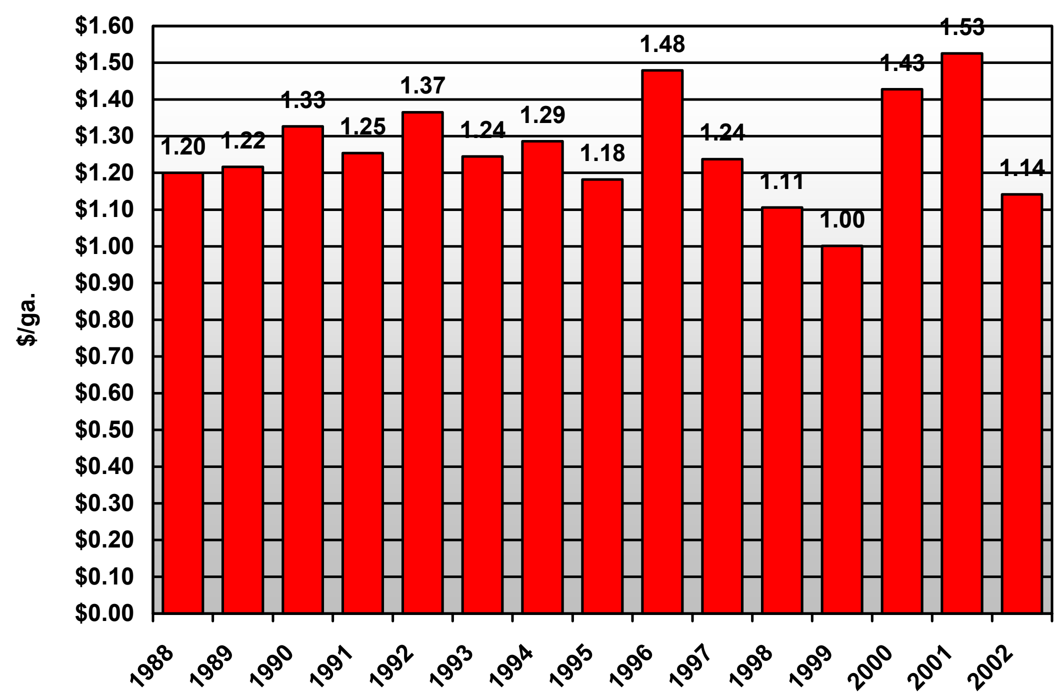
Minnesota Fuel Ethanol Price* Trend

Mpls/St. Paul: 1987-2002 Average = $1.27

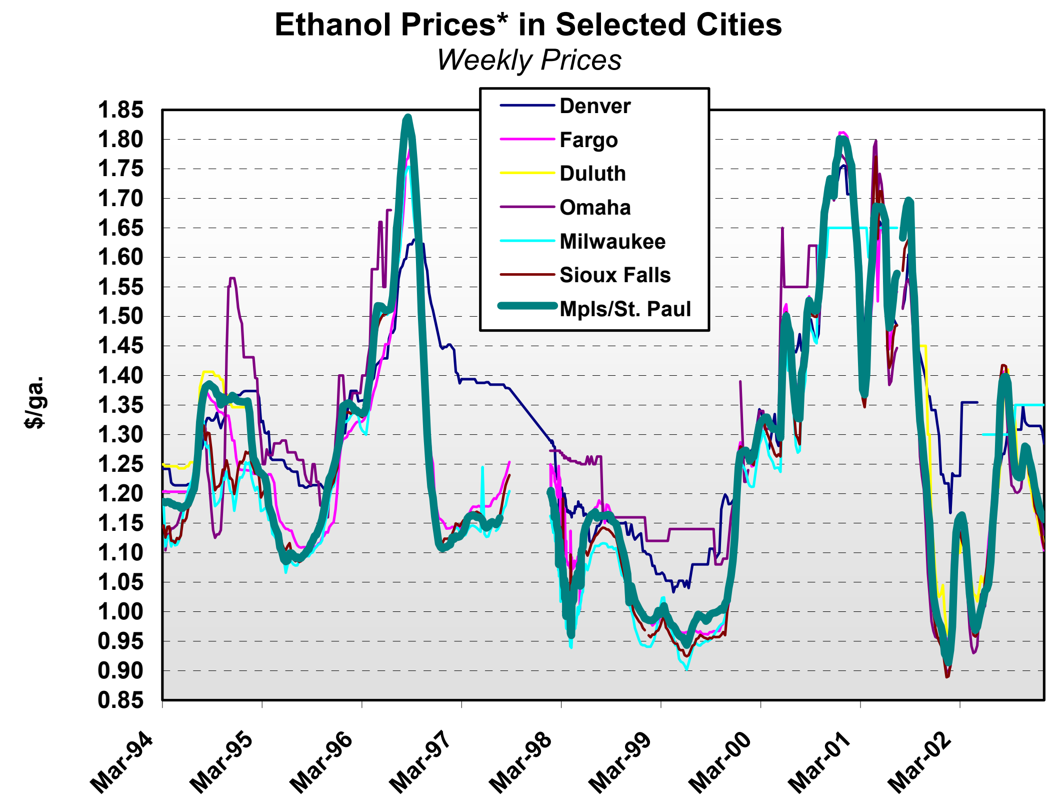


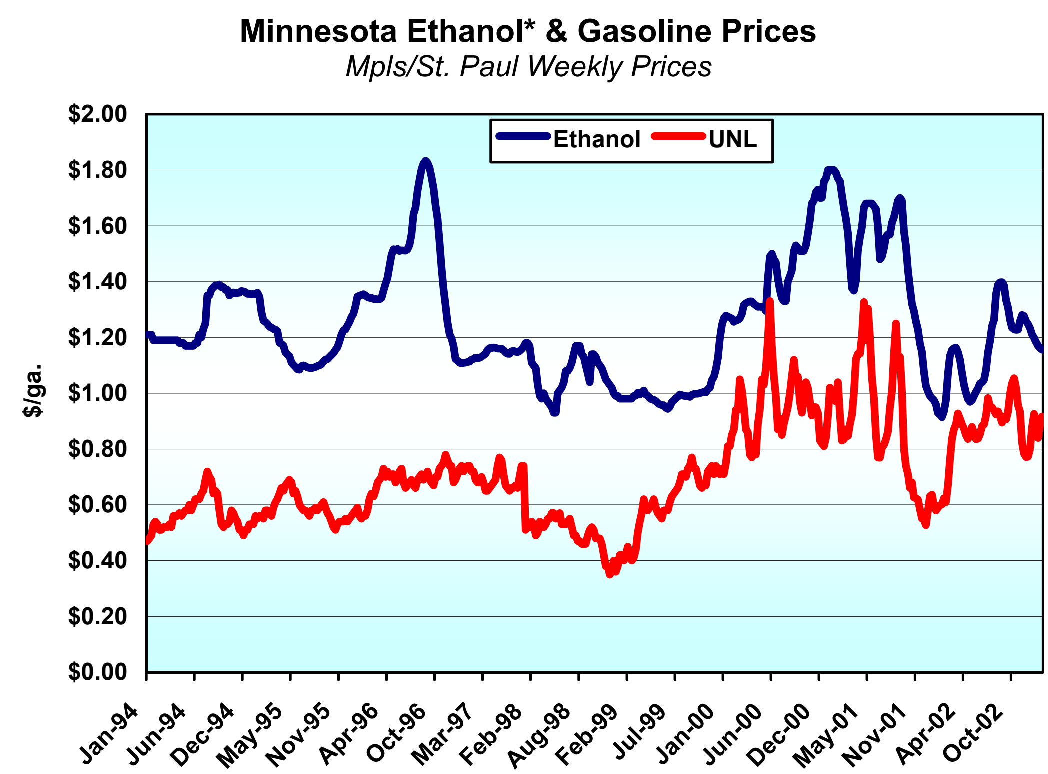
Minnesota Ethanol Prices*, Annual Average

Mpls/St. Paul



**Rack prices: Wholesale bulk prices at the terminal.*
Source: Axxis Petroleum.

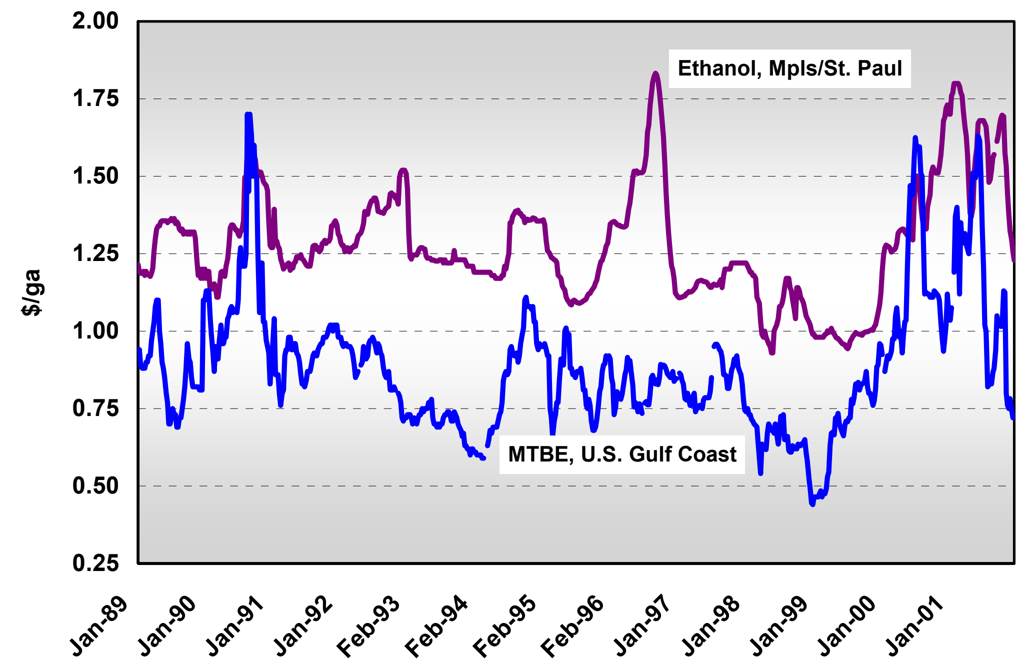




**Rack prices: Wholesale bulk prices at the terminal.*
Source: Axxis Petroleum.

Ethanol* and MTBE Prices

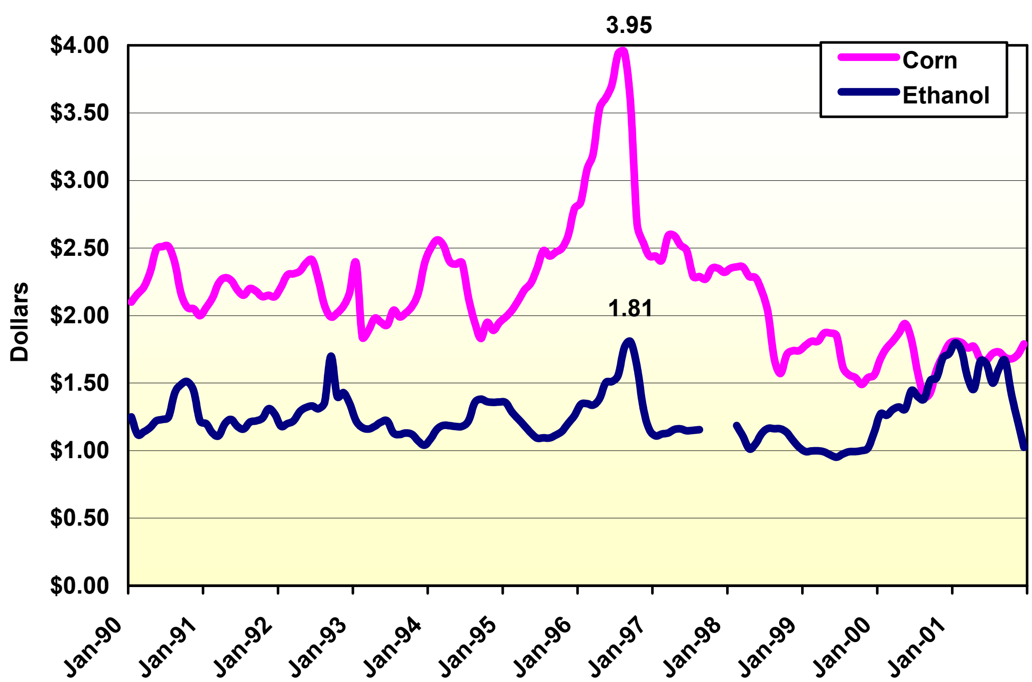
1989-2001



MTBE: Methyl Tertiary Butyl Ether – a petroleum oxygenate for gasoline.

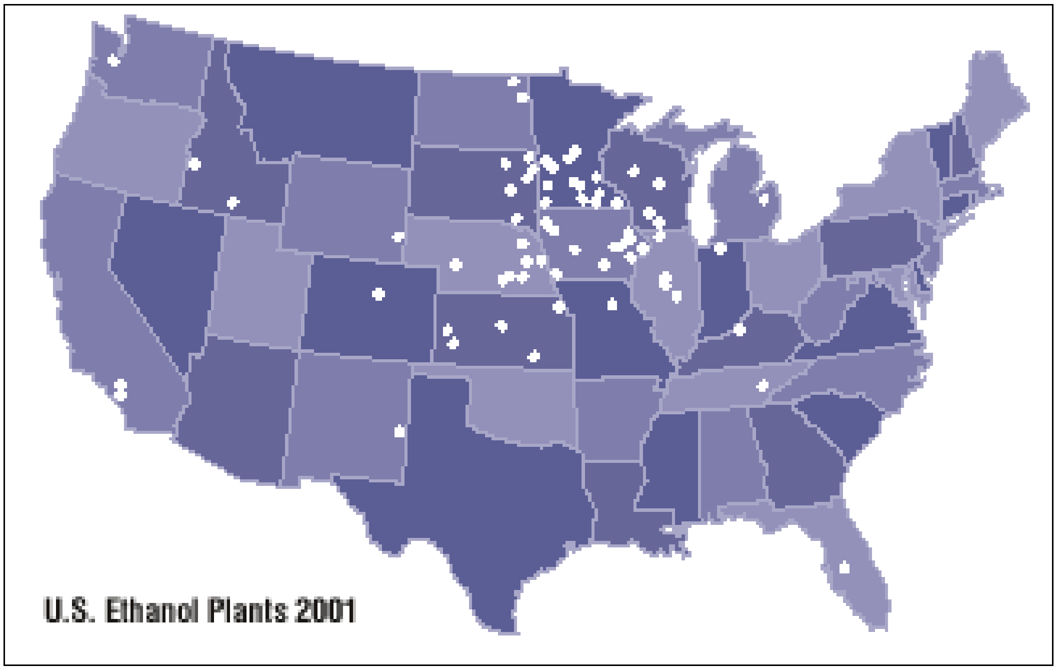
Minnesota Corn & Ethanol* Prices

Monthly Prices



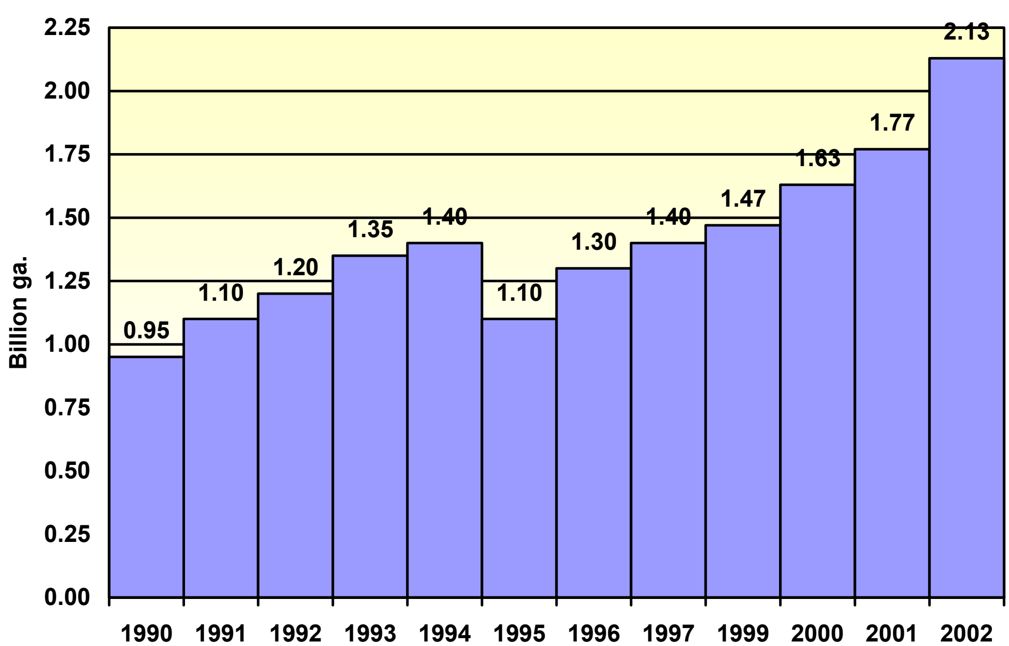
**Rack prices: Wholesale bulk prices at the terminal.*
Source: Minnesota Agricultural Statistics, Axxis Petroleum, and Oxy Fuels.

U.S. Ethanol Plants (2001)

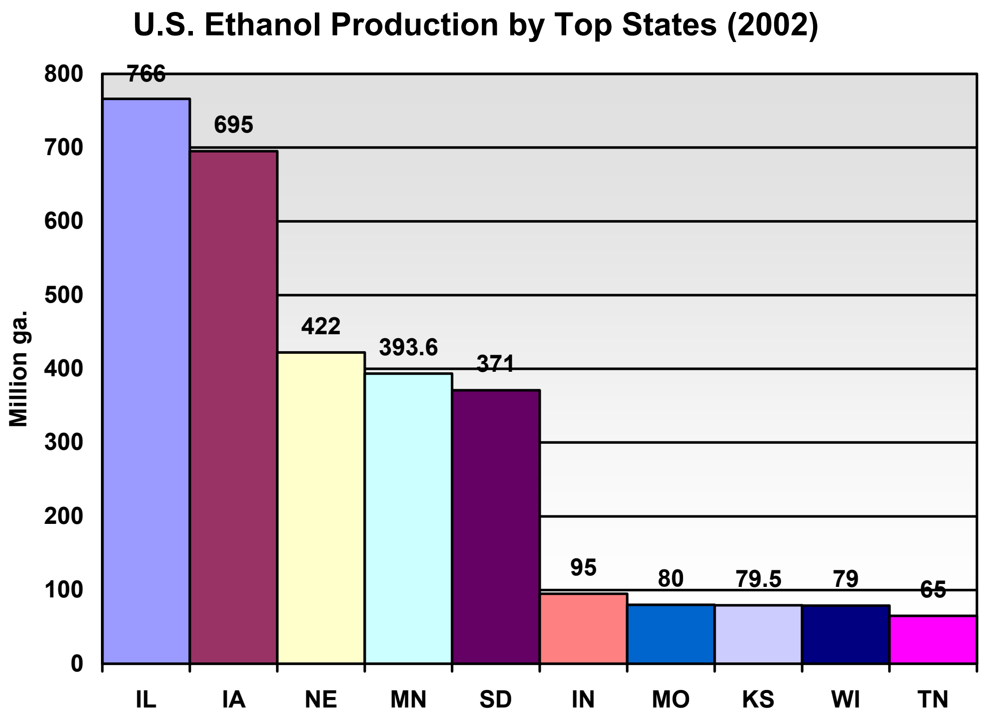


Source: National Corn Growers Association.

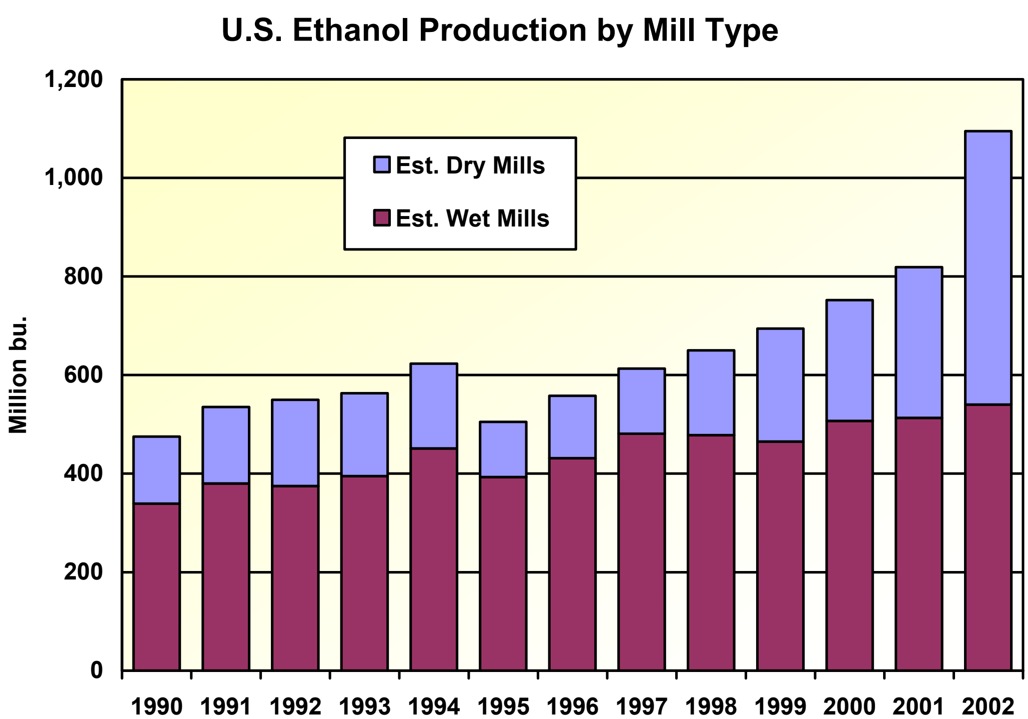
U.S. Ethanol Production



Source: Renewable Fuels Association.

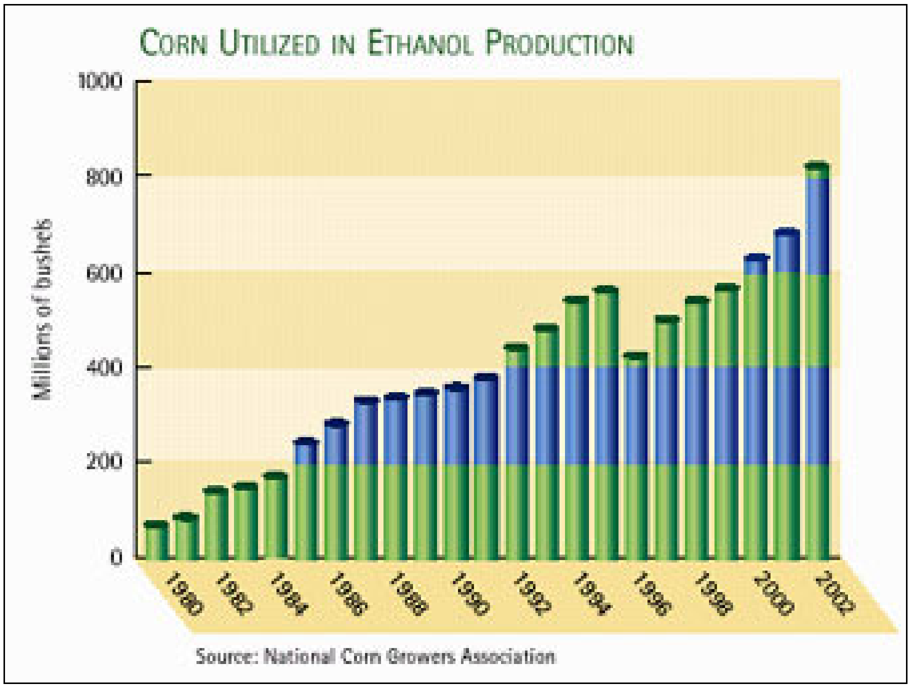


Source: Renewable Fuels Association.

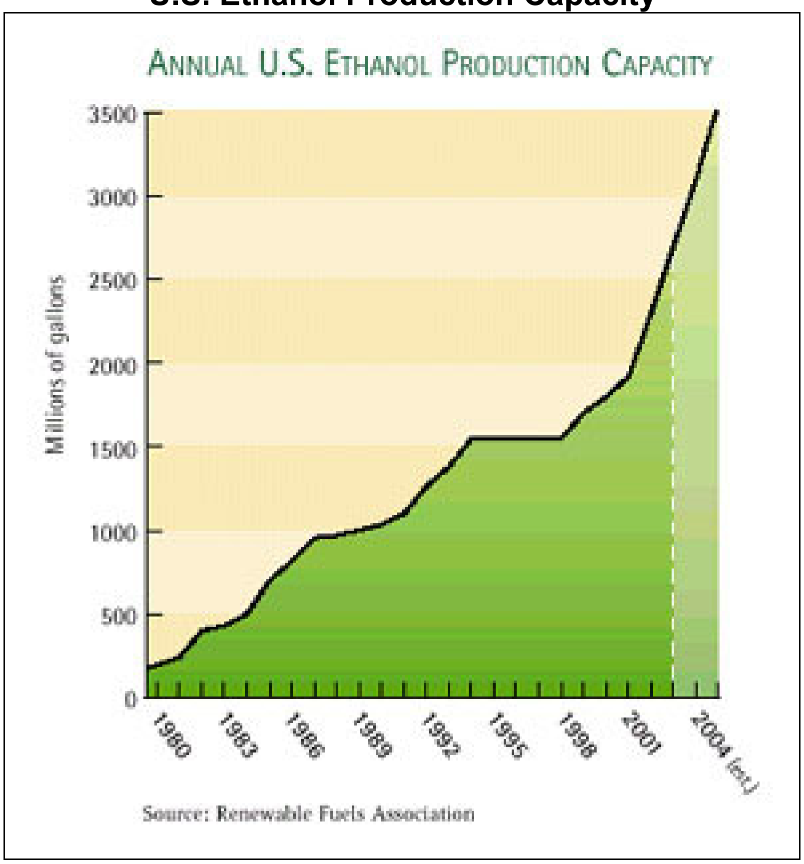


Source: ProExporter Network (PRX).

U.S. Corn Utilized for Ethanol Production

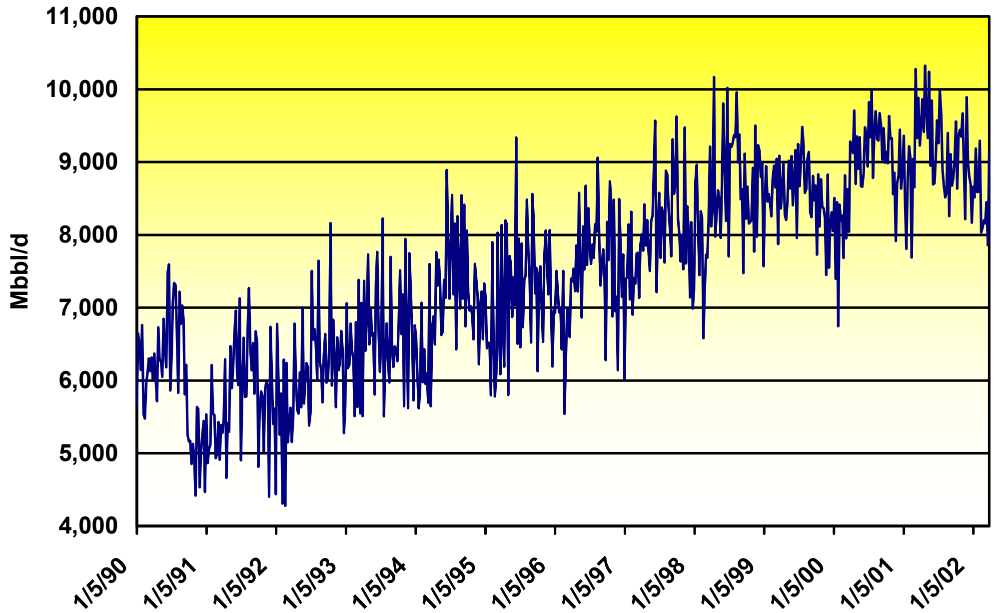


U.S. Ethanol Production Capacity



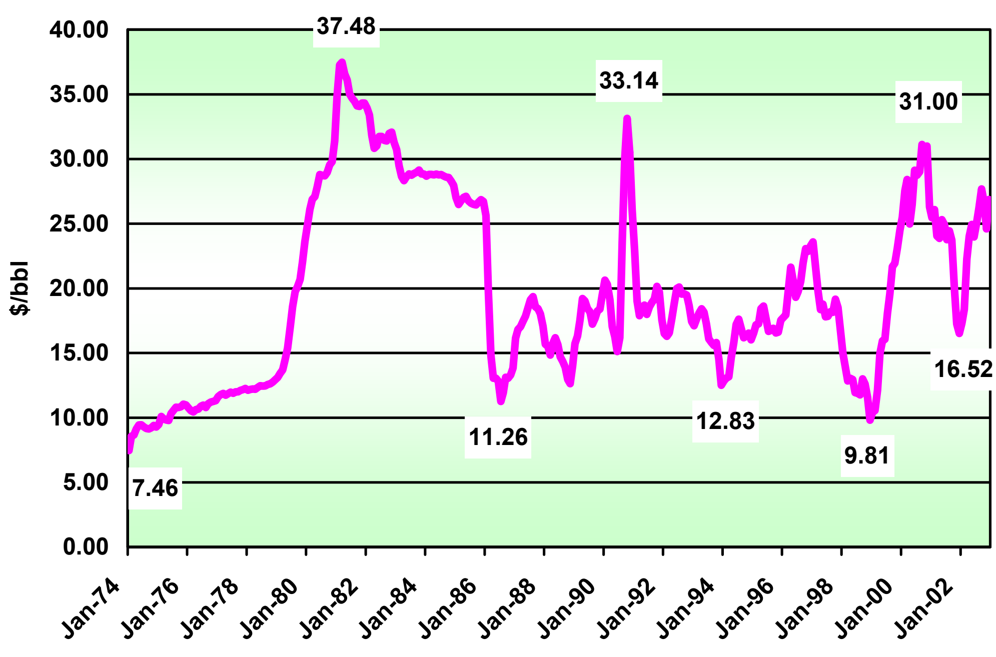
U.S. Crude Oil Imports (1990-2002)

Weekly Imports



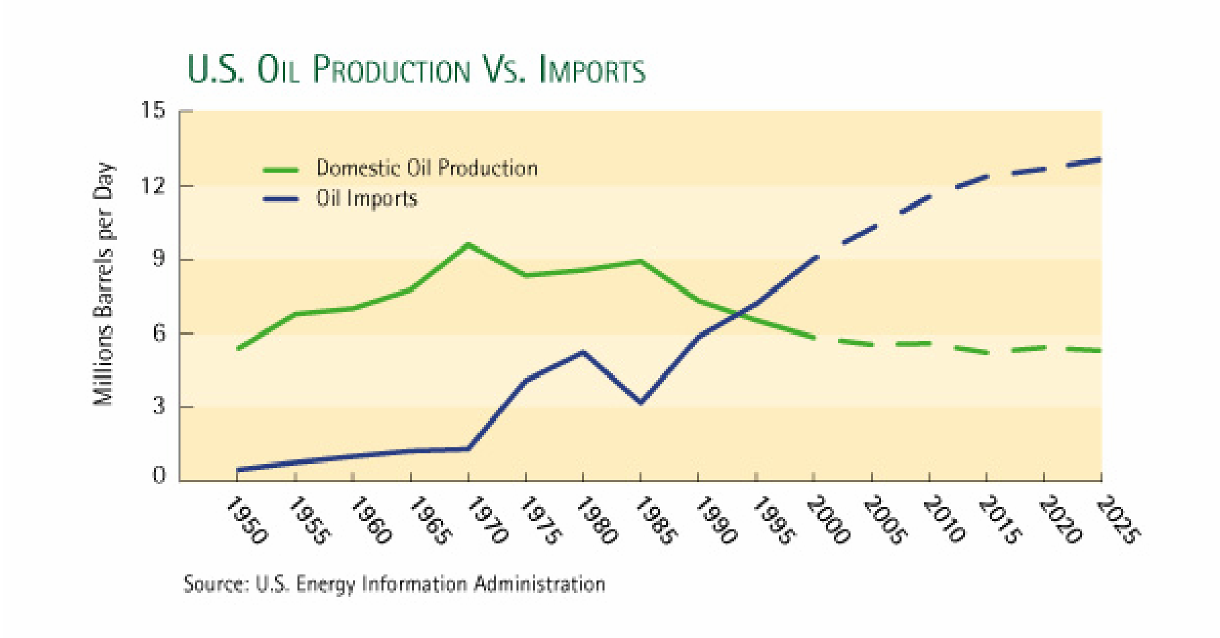
Source: U.S. Department of Energy.

U.S. Crude Oil Prices (1974-2002)

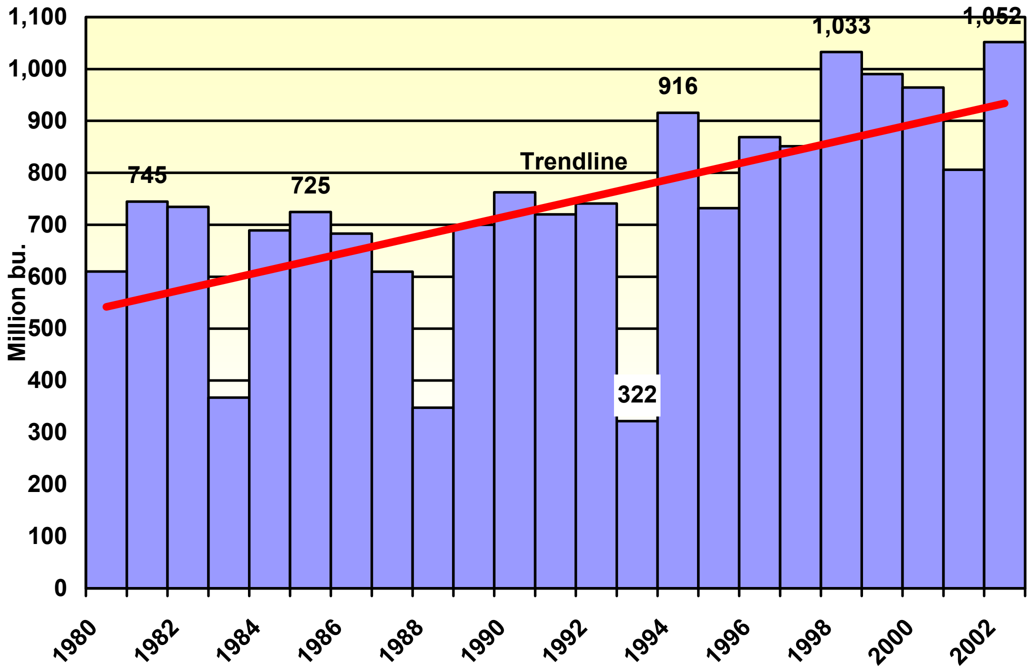


Source: U.S. Department of Energy.

U.S. Oil Production vs. Imports

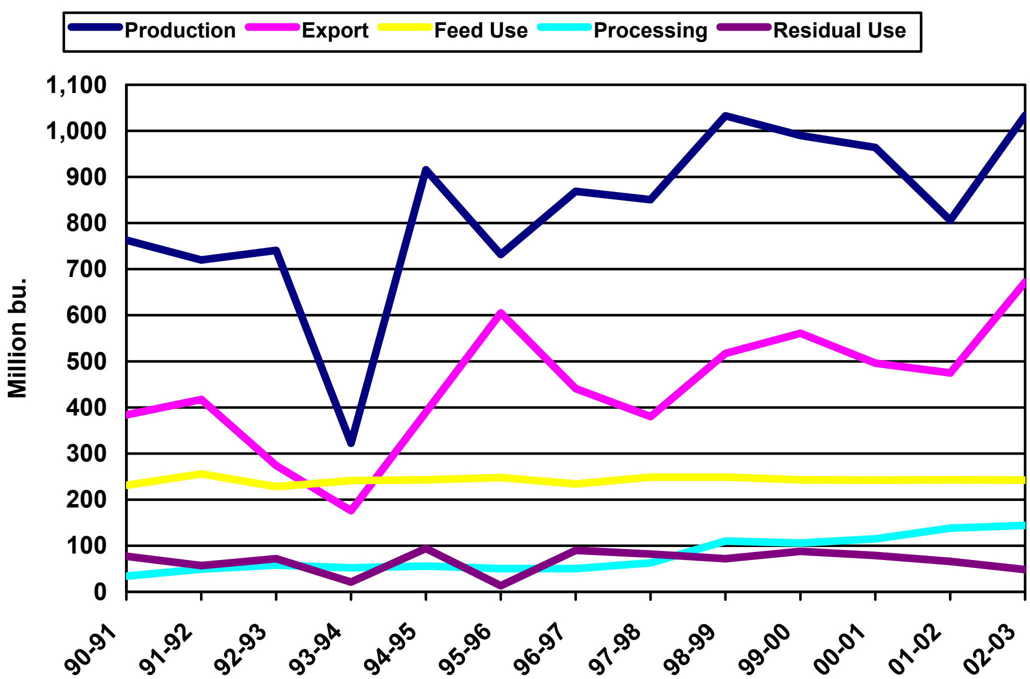


Minnesota Corn Production



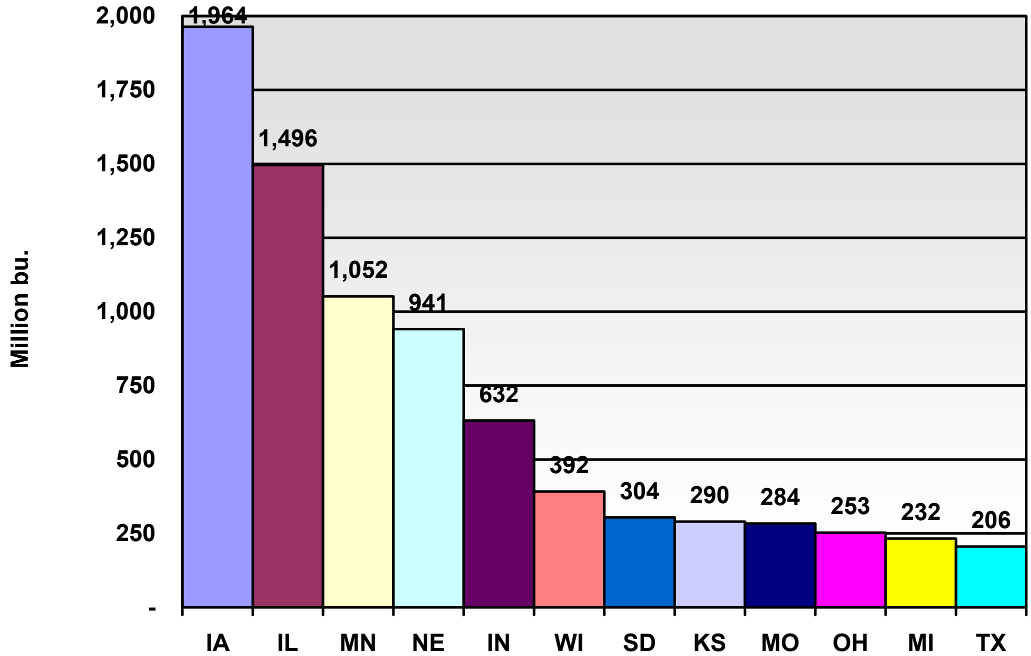
Source: USDA.

Minnesota Corn Utilization



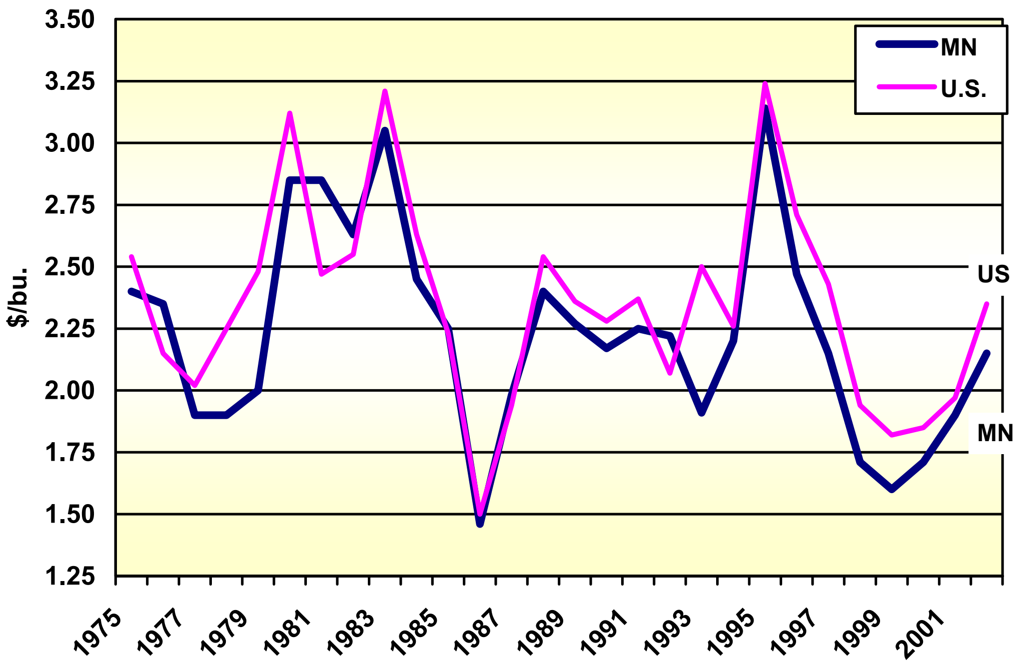
Source: PRX.

U.S. Top Corn States
(2002)



Source: USDA.

Corn Prices: MN & U.S. Average
Annual Average Prices



Source: USDA.

U.S. Top Corn States:
Comparing Corn Production, Processing, and Prices

Production *(Million Bushels)*

Crop Year	Rank (2002-2003 Crop Year)					U.S. Total
	1	2	3	4	5	
	IA	IL	MN	NE	IN	
90-91	1,562	1,321	**763**	934	703	7,934
91-92	1,427	1,177	**720**	991	511	7,475
92-93	1,904	1,646	**741**	1,067	878	9,477
93-94	880	1,300	**322**	785	713	6,338
94-95	1,915	1,786	**916**	1,147	858	10,051
95-96	1,427	1,130	**732**	855	599	7,400
96-97	1,711	1,469	**869**	1,180	670	9,233
97-98	1,642	1,425	**851**	1,135	702	9,207
98-99	1,769	1,473	**1,033**	1,240	760	9,759
99-00	1,758	1,491	**990**	1,154	748	9,431
00-01	1,728	1,669	**964**	1,014	810	9,915
01-02	1,664	1,649	**806**	1,139	885	9,507
02-03	1,964	1,496	**1,052**	941	632	9,008

Processing *(Million Bushels)*

Crop Year	Rank (2002-2003 Crop Year)					U.S. Total
	1	2	3	4	5	
	IA	IL	NE	IN	MN	
90-91	416	380	54	145	**34**	1,405
91-92	457	407	63	152	**49**	1,514
92-93	461	429	71	147	**58**	1,542
93-94	490	441	70	152	**52**	1,592
94-95	515	468	121	159	**56**	1,694
95-96	479	429	126	153	**50**	1,607
96-97	500	463	136	163	**50**	1,693
97-98	558	504	143	169	**63**	1,781
98-99	587	485	154	155	**110**	1,826
99-00	572	519	179	173	**106**	1,910
00-01	588	536	190	177	**115**	1,968
01-02	593	536	205	182	**138**	2,038
02-03	642	557	214	183	**144**	2,175

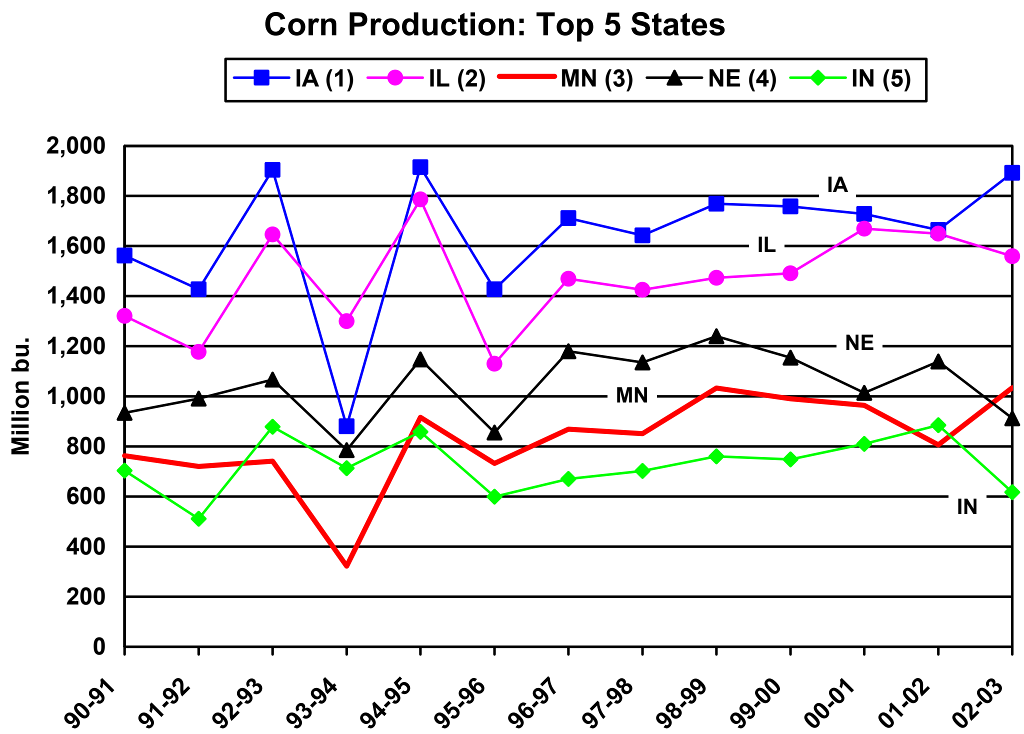
Source: PRX.

U.S. Top Corn States:
Comparing Corn Production, Processing, and Prices (continued)

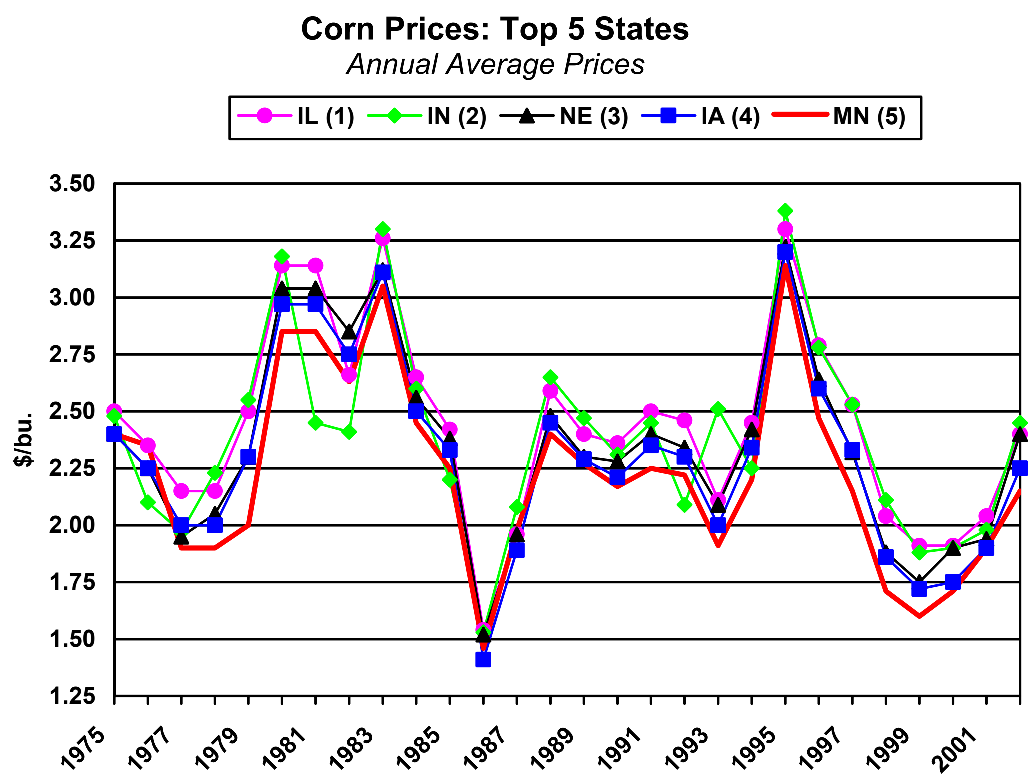
Prices *(Dollar per Bushel)*

Year	Rank (2002)					U.S. Average	U.S. High	U.S. Low
	1	2	3	4	5			
	IL	IN	NE	IA	MN			
1980	3.15	3.18	3.08	3.00	**2.91**	3.12	3.18	2.91
1981	2.52	2.45	2.47	2.34	**2.24**	2.47	2.52	2.24
1982	2.61	2.41	2.82	2.69	**2.57**	2.55	2.82	2.41
1983	3.26	3.30	3.13	3.12	**3.06**	3.21	3.30	3.06
1984	2.66	2.60	2.58	2.51	**2.47**	2.63	2.66	2.47
1985	2.27	2.20	2.22	2.02	**2.05**	2.23	2.27	2.02
1986	1.54	1.53	1.52	1.41	**1.46**	1.50	1.54	1.41
1987	1.96	2.08	1.96	1.89	**1.98**	1.94	2.08	1.89
1988	2.59	2.65	2.48	2.45	**2.40**	2.54	2.65	2.40
1989	2.40	2.47	2.30	2.29	**2.27**	2.36	2.47	2.27
1990	2.36	2.31	2.28	2.21	**2.17**	2.28	2.36	2.17
1991	2.46	2.45	2.34	2.30	**2.22**	2.37	2.46	2.22
1992	2.11	2.09	2.09	2.00	**1.91**	2.07	2.11	1.91
1993	2.57	2.51	2.52	2.44	**2.26**	2.50	2.57	2.26
1994	2.27	2.25	2.33	2.22	**2.23**	2.26	2.33	2.22
1995	3.30	3.38	3.22	3.20	**3.14**	3.24	3.38	3.14
1996	2.79	2.78	2.64	2.60	**2.47**	2.71	2.79	2.47
1997	2.53	2.53	2.32	2.33	**2.15**	2.43	2.53	2.15
1998	2.04	2.11	1.88	1.86	**1.71**	1.94	2.11	1.71
1999	1.91	1.88	1.75	1.72	**1.60**	1.82	1.91	1.60
2000	1.91	1.90	1.90	1.75	**1.71**	1.85	1.91	1.71
2001	2.04	1.98	1.94	1.90	**1.90**	1.97	2.04	1.90
2002	2.40	2.45	2.40	2.25	**2.15**	2.35	2.45	2.15
Average	2.42	2.41	2.36	2.28	**2.22**	2.36	2.42	2.22
Price difference between IL & MN					**0.20**			
Price difference between US & MN					**0.14**			

Source: USDA, NASS.



Source: USDA.



Source: USDA.

Value of Corn
Raw Commodity vs. Value-Added
(per bushel of corn)

1. July 2002 Prices

	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw	Starch &	Ethanol &	Sweeteners & Products		Ethanol &
Products	Commodity	Products	Products	Corn Syrup	HFCS	DDG
Corn	$2.17					
Corn Oil		$0.29	$0.29	$0.29	$0.29	
Gluten Feed		$0.28	$0.28	$0.28	$0.28	
Gluten Meal		$0.41	$0.41	$0.41	$0.41	
Starch		$4.03				
Ethanol			$2.76			$2.91
Corn Syrup				$4.70		
HFCS					$3.60	
DDG						$0.65
Total Value	**$2.17**	**$5.02**	**$3.76**	**$5.69**	**$4.59**	**$3.56**

2. December 2002 Prices

	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw	Starch &	Ethanol &	Sweeteners & Products		Ethanol &
Products	Commodity	Products	Products	Corn Syrup	HFCS	DDG
Corn	$2.11					
Corn Oil		$0.44	$0.44	$0.44	$0.44	
Gluten Feed		$0.35	$0.35	$0.35	$0.35	
Gluten Meal		$0.30	$0.30	$0.30	$0.30	
Starch		$4.15				
Ethanol			$3.00			$3.16
Corn Syrup				$5.10		
HFCS					$3.83	
DDG						$0.67
Total Value	**$2.11**	**$5.24**	**$4.09**	**$6.19**	**$4.92**	**$3.83**

Computation based on the following:
Corn prices (Minneapolis Grain Exchange)
Corn oil prices (Wall Street Journal)
Gluten feed prices (USDA, Grain & Feed Market News)
Gluten meal prices (USDA, Grain & Feed Market News)
Starch prices (USDA, ERS)
Ethanol prices (Mpls/St. Paul market, Axxis Petroleum)
Corn syrup prices (Milling & Baking News)
HFCS prices (Milling & Baking News)
DDG prices (USDA, Grain & Feed Market News)

Value of Corn
Raw Commodity vs. Value-Added
(per bushel of corn)

1. July 2000 Prices

	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw	Starch &	Ethanol &	Sweeteners & Products		Ethanol &
Products	Commodity	Products	Products	Corn Syrup	HFCS	DDG
Corn	$1.48					
Corn Oil		$0.21	$0.21	$0.21	$0.21	
Gluten Feed		$0.22	$0.22	$0.22	$0.22	
Gluten Meal		$0.26	$0.26	$0.26	$0.26	
Starch		$4.02				
Ethanol			$3.43			$3.61
Corn Syrup				$4.10		
HFCS					$4.91	
DDG						$0.59
Total Value	**$1.48**	**$4.71**	**$4.12**	**$4.79**	**$5.60**	**$4.20**

2. December 2000 Prices

	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw	Starch &	Ethanol &	Sweeteners & Products		Ethanol &
Products	Commodity	Products	Products	Corn Syrup	HFCS	DDG
Corn	$1.85					
Corn Oil		$0.16	$0.16	$0.16	$0.16	
Gluten Feed		$0.33	$0.33	$0.33	$0.33	
Gluten Meal		$0.32	$0.32	$0.32	$0.32	
Starch		$4.06				
Ethanol			$4.25			$4.48
Corn Syrup				$4.26		
HFCS					$4.91	
DDG						$0.71
Total Value	**$1.85**	**$4.87**	**$5.06**	**$5.07**	**$5.72**	**$5.18**

Computation based on the following:
Corn prices (Minneapolis Grain Exchange)
Corn oil prices (Wall Street Journal)
Gluten feed prices (USDA, Grain & Feed Market News)
Gluten meal prices (USDA, Grain & Feed Market News)
Starch prices (USDA, ERS)
Ethanol prices (Mpls/St. Paul market, Axxis Petroleum)
Corn syrup prices (Milling & Baking News)
HFCS prices (Milling & Baking News)
DDG prices (USDA, Grain & Feed Market News)

Value of Corn *(continued)*
Raw Commodity vs. Value-Added
(per bushel of corn)

3. July 1998 Prices

Products	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw Commodity	Starch & Products	Ethanol & Products	Sweeteners & Products: Corn Syrup	Sweeteners & Products: HFCS	Ethanol & DDG
Corn	$2.14					
Corn Oil		$0.50	$0.50	$0.50	$0.50	
Gluten Feed		$0.29	$0.29	$0.29	$0.29	
Gluten Meal		$0.30	$0.30	$0.30	$0.30	
Starch		$4.06				
Ethanol			$2.85			$3.00
Corn Syrup				$3.96		
HFCS					$3.54	
DDG						$0.66
Total Value	**$2.14**	**$5.14**	**$3.94**	**$5.05**	**$4.63**	**$3.67**

4. December 1998 Prices

Products	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw Commodity	Starch & Products	Ethanol & Products	Sweeteners & Products: Corn Syrup	Sweeteners & Products: HFCS	Ethanol & DDG
Corn	$1.86					
Corn Oil		$0.47	$0.47	$0.47	$0.47	
Gluten Feed		$0.37	$0.37	$0.37	$0.37	
Gluten Meal		$0.34	$0.34	$0.34	$0.34	
Starch		$3.81				
Ethanol			$2.51			$2.64
Corn Syrup				$3.90		
HFCS					$3.45	
DDG						$0.69
Total Value	**$1.86**	**$4.99**	**$3.69**	**$5.08**	**$4.63**	**$3.33**

Computation based on the following:
Corn prices (Minneapolis Grain Exchange)
Corn oil prices (Wall Street Journal)
Gluten feed prices (USDA, Grain & Feed Market News)
Gluten meal prices (USDA, Grain & Feed Market News)
Starch prices (USDA, ERS)
Ethanol prices (Mpls/St. Paul market, Axxis Petroleum)
Corn syrup prices (Milling & Baking News)
HFCS prices (Milling & Baking News)
DDG prices (USDA, Grain & Feed Market News)

Value of Corn *(continued)*
Raw Commodity vs. Value-Added
(per bushel of corn)

5. July 1996 Prices

	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw	Starch &	Ethanol &	Sweeteners & Products		Ethanol &
Products	Commodity	Products	Products	Corn Syrup	HFCS	DDG
Corn	$4.68					
Corn Oil		$0.40	$0.40	$0.40	$0.40	
Gluten Feed		$0.54	$0.54	$0.54	$0.54	
Gluten Meal		$0.36	$0.36	$0.36	$0.36	
Starch		$5.87				
Ethanol			$3.85			$4.06
Corn Syrup				$5.26		
HFCS					$6.86	
DDG						$1.28
Total Value	**$4.68**	**$7.18**	**$5.16**	**$6.57**	**$8.17**	**$5.33**

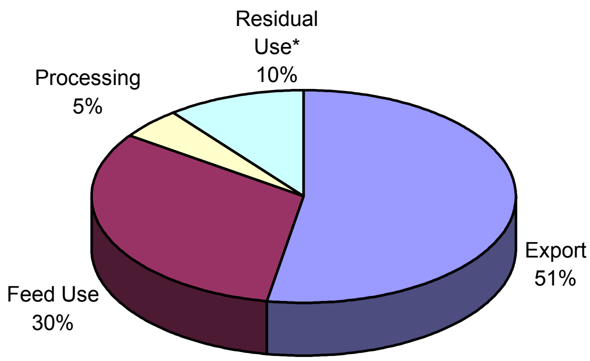
6. December 1996 Prices

	Corn	Value-Added				
		Wet-Milling				Dry-Milling
	Raw	Starch &	Ethanol &	Sweeteners & Products		Ethanol &
Products	Commodity	Products	Products	Corn Syrup	HFCS	DDG
Corn	$2.46					
Corn Oil		$0.35	$0.35	$0.35	$0.35	
Gluten Feed		$0.49	$0.49	$0.49	$0.49	
Gluten Meal		$0.40	$0.40	$0.40	$0.40	
Starch		$4.08				
Ethanol			$2.84			$2.99
Corn Syrup				$5.26		
HFCS					$6.86	
DDG						$1.15
Total Value	**$2.46**	**$5.33**	**$4.08**	**$6.51**	**$8.11**	**$4.13**

Computation based on the following:
Corn prices (Minneapolis Grain Exchange)
Corn oil prices (Wall Street Journal)
Gluten feed prices (USDA, Grain & Feed Market News)
Gluten meal prices (USDA, Grain & Feed Market News)
Starch prices (USDA, ERS)
Ethanol prices (Mpls/St. Paul market, Axxis Petroleum)
Corn syrup prices (Milling & Baking News)
HFCS prices (Milling & Baking News)
DDG prices (USDA, Grain & Feed Market News)

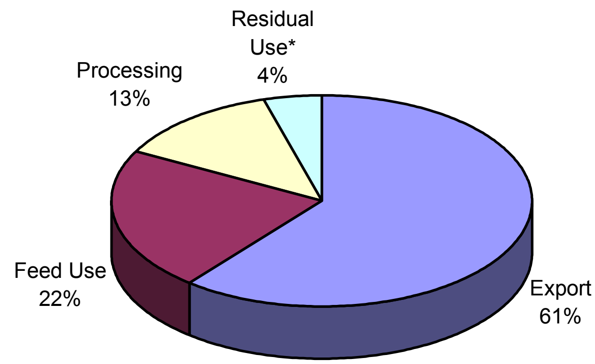
Minnesota Corn Utilization

<u>1990-1991 Crop Year</u>



Total Production: 763 million bu.

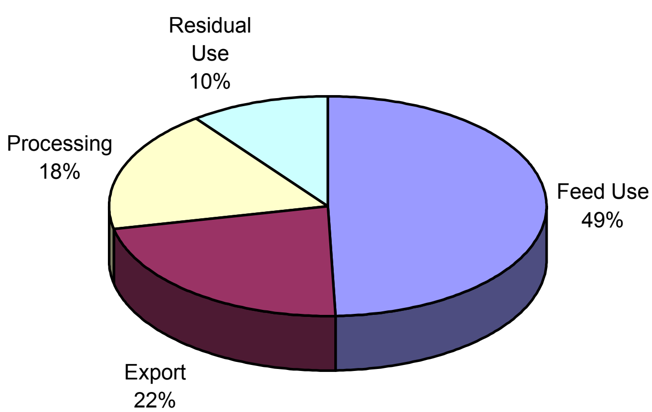
<u>2002-2003 Crop Year</u>



Total Production: 1,052 million bu.

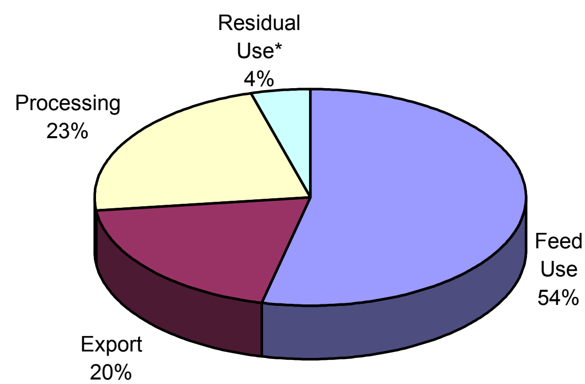
U.S. Corn Utilization

<u>1990-1991 Crop Year</u>



Total Production: 7,934 million bu.

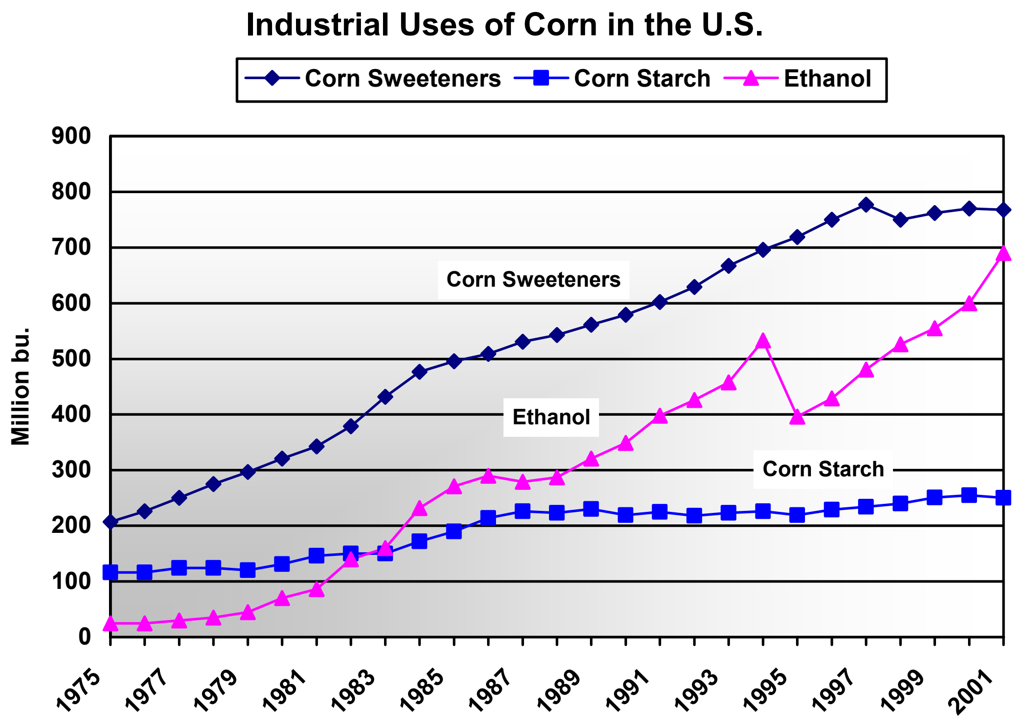
<u>2002-2003 Crop Year</u>

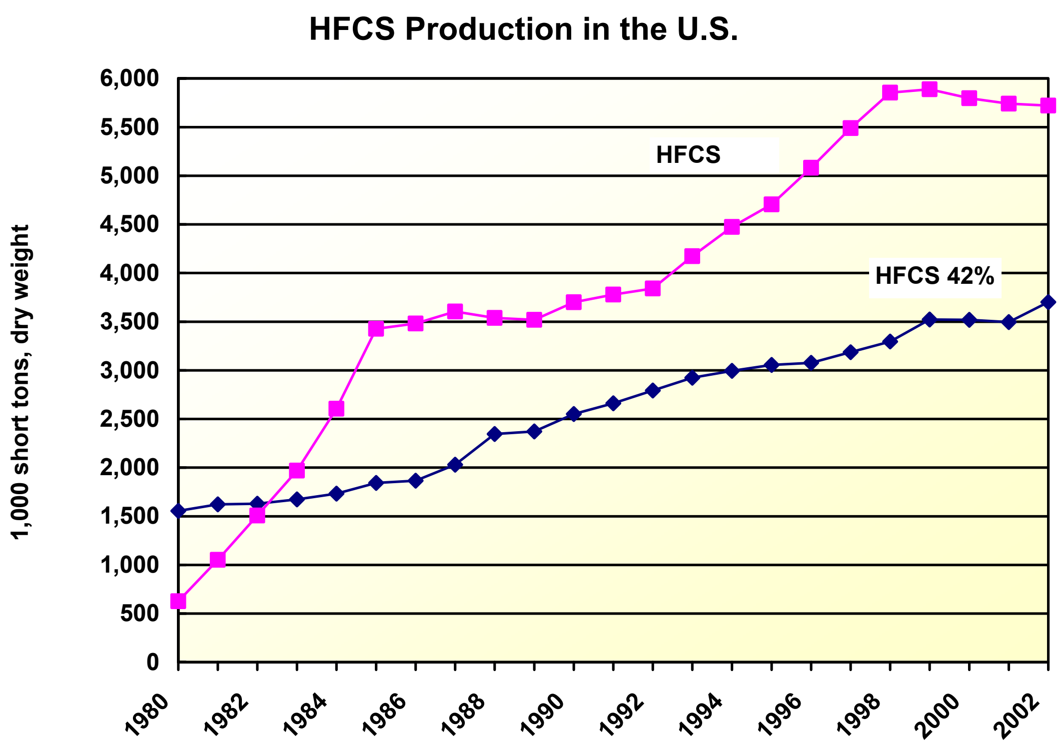


Total Production: 9,008 million bu.

** Residual use: All other uses.*

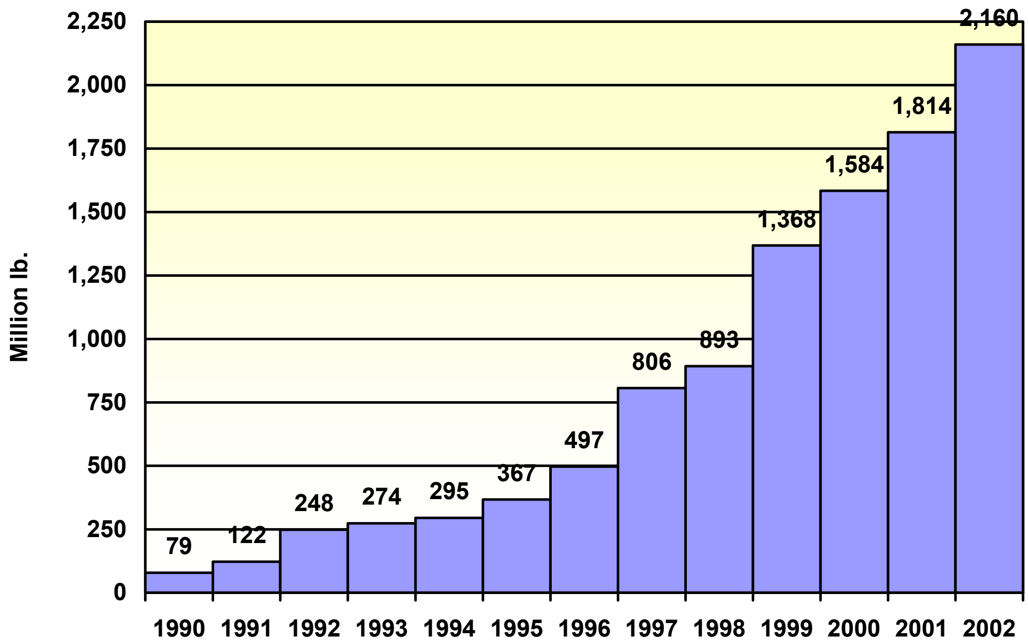
Source: PRX.


Industrial Uses of Corn in the U.S.
Corn Sweeteners
Corn Starch
Ethanol
Million bu.
900
800
700
600
500
400
300
200
100
0
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001


HFCS Production in the U.S.
HFCS
HFCS 42%
1,000 short tons, dry weight
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

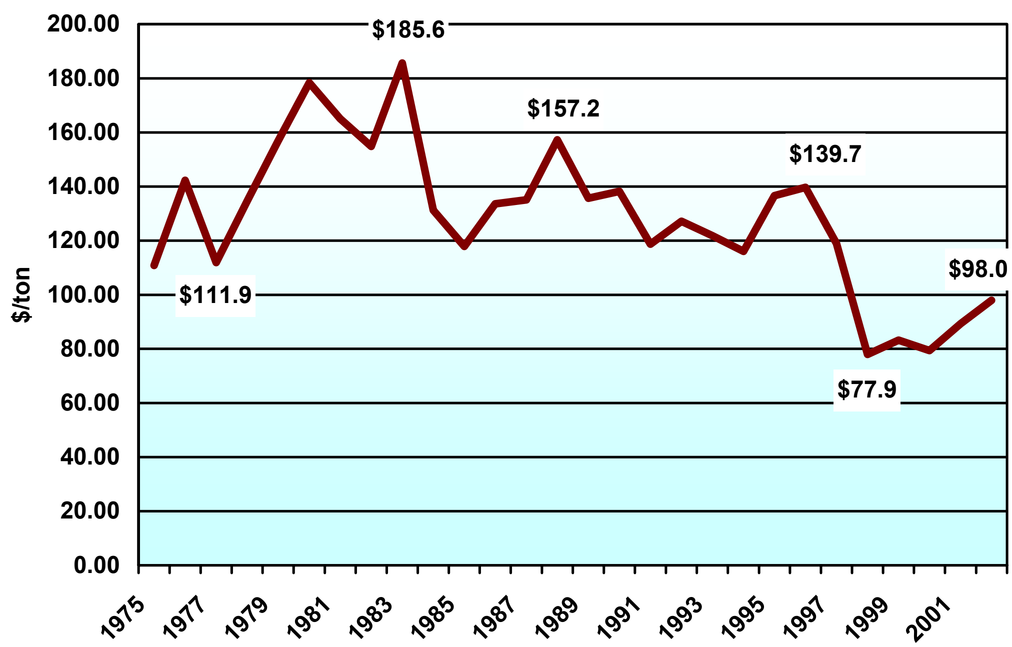
Source: USDA.

Minnesota DDG Production



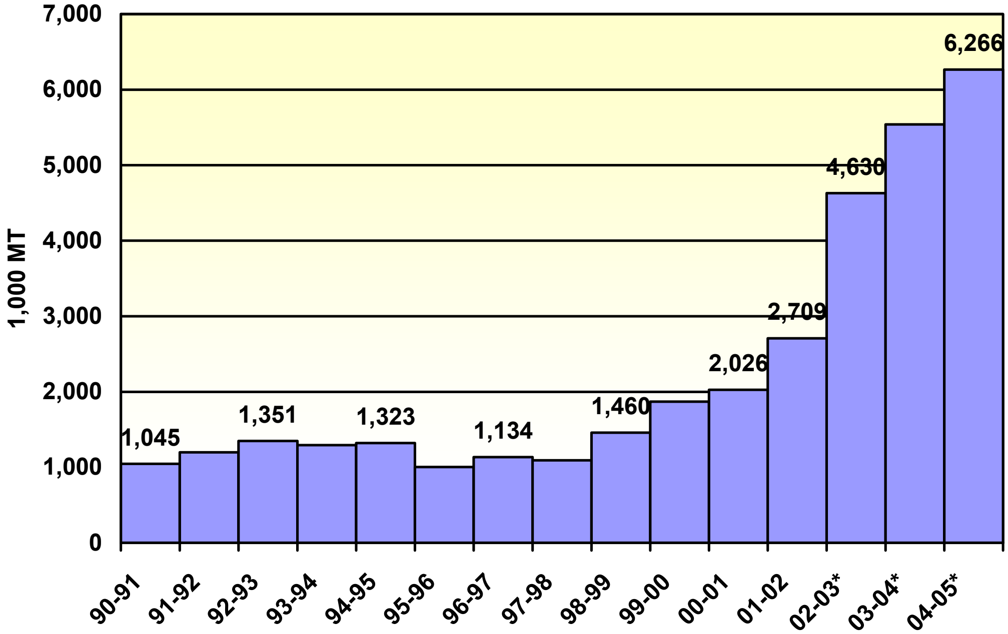
DDG Prices

Annual Average (1975-2002)- IL point



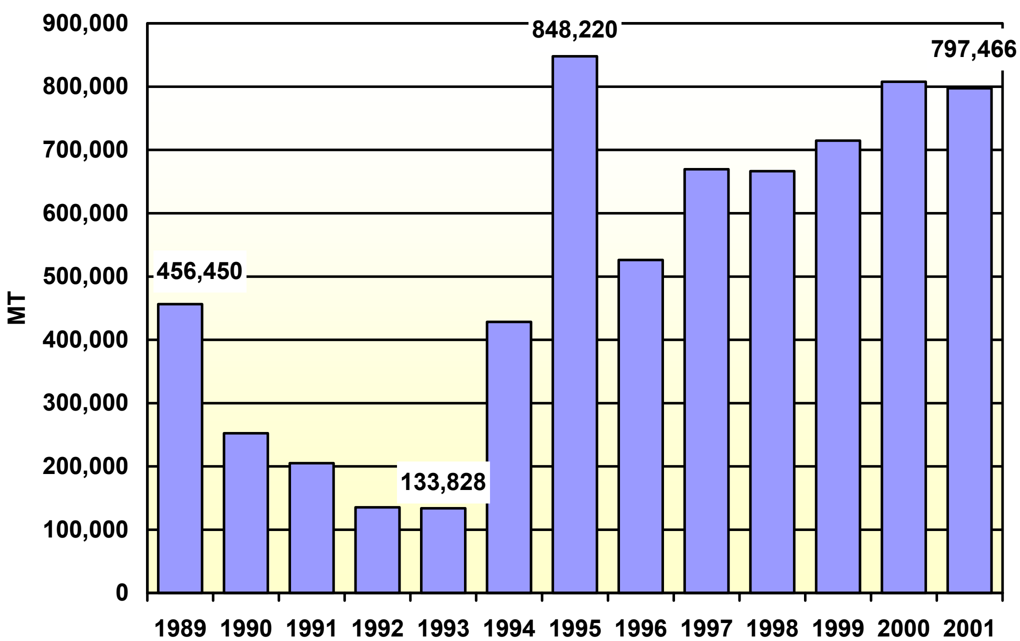
Source: USDA.

U.S. DDG Production



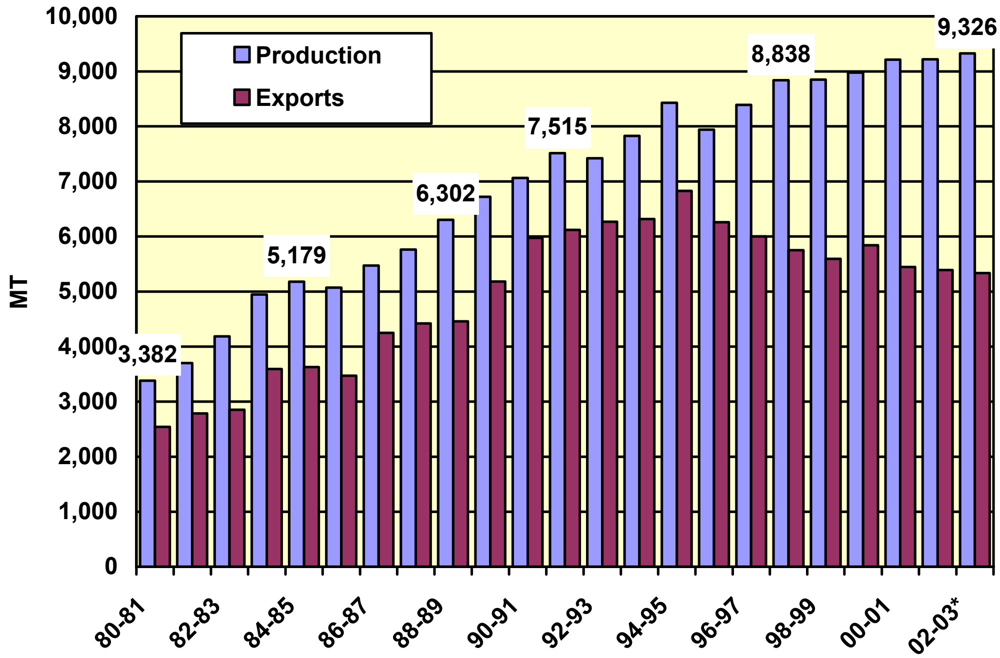
**Projected.*
Source: PRX.

U.S. DDG Exports



Source: USDA, FAS.

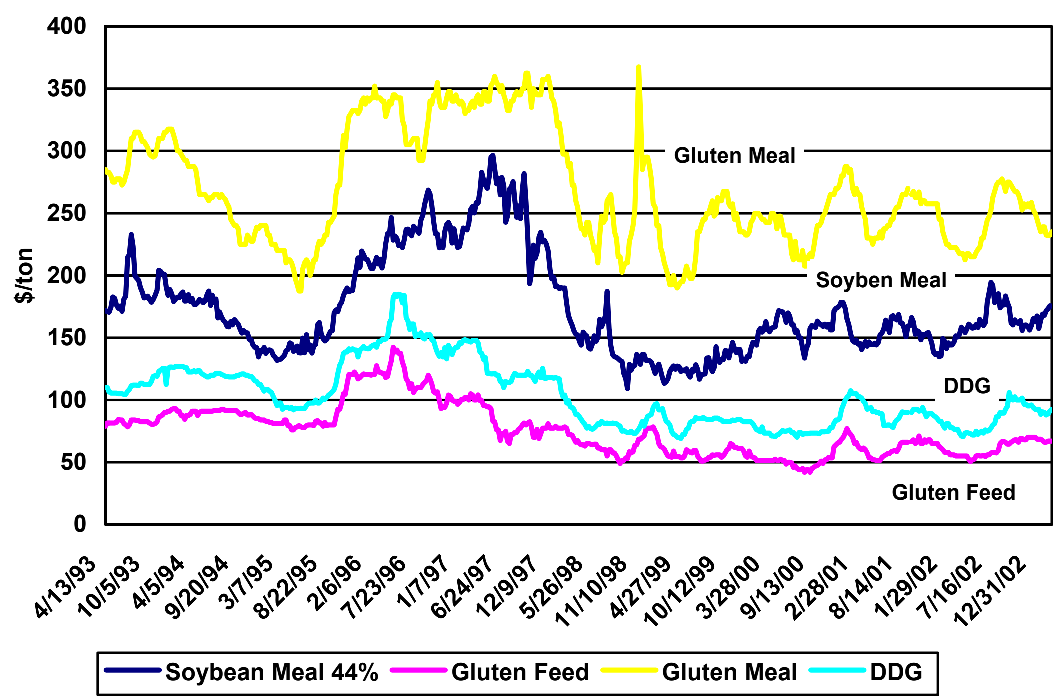
U.S. Corn Gluten Feed and Meal Production



**Projected.*
Source: PRX.

Protein Feed Prices

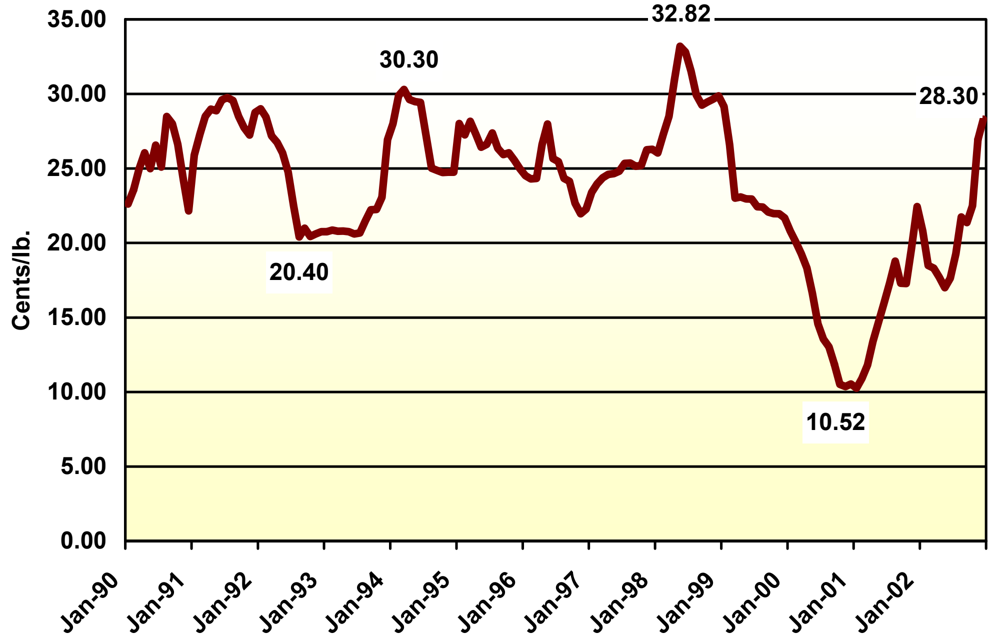
Weekly Prices - 1993-2003



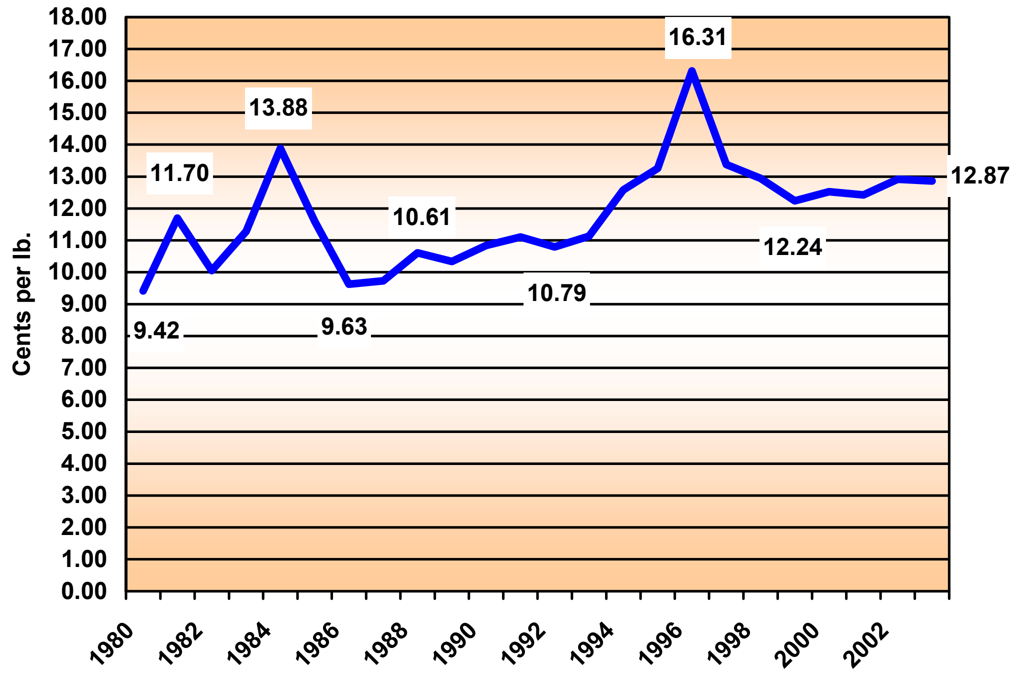
Source: USDA.

Corn Oil Prices

Midwest



Corn Starch Prices



Source: USDA, AMS, Market News Service.

MINNESOTA DEPARTMENT OF AGRICULTURE
FROM THE FARM TO YOUR FAMILY

For more information, please contact:

Su Ye
Program Leader, Market Research
Minnesota Department of Agriculture
90 West Plato Boulevard
St. Paul, MN 55107
Tel: 651-296-6384
Fax: 651-296-6890
E-mail: su.ye@state.mn.us

THE 2001 NET ENERGY BALANCE OF CORN-ETHANOL

Hosein Shapouri*, U.S. Department of Agriculture (USDA), Office of the Chief Economist (OCE), 300 7th Street SW., Room 361, Washington, D.C. 20024, telephone: 202 401 0531, James Duffield, USDA/OCE, Andrew McAloon, USDA/Agricultural Research Service (ARS), Eastern Regional Research Center, 600 East Mermaid Lane, Wyndmoor, PA. 19038, and Michael Wang, U.S. Department of Energy, Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL. 60439

ABSTRACT

This report estimates the net energy balance of corn ethanol utilizing the latest survey of U.S. corn producers and the 2001 U.S. survey of ethanol plants. The major objectives of this report are to improve the quality of data and methodology used in the estimation. This paper also uses ASPEN Plus, a process simulation program, to allocate total energy used to produce ethanol and byproducts. The results indicate that corn ethanol has a positive energy balance, even before subtracting the energy allocated to by products. The net energy balance of corn ethanol adjusted for byproduct credits is 27,729 and 33,196 Btu per gallon for wet- and dry-milling, respectively, and 30,528 Btu per gallon for the industry. The study results suggest that corn ethanol is energy efficient, as indicated by an energy output/input ratio of 1.67.

Keywords: Corn-ethanol, energy inputs, dry-and wet-milling, net energy balance

INTRODUCTION

USDA's net energy balance of corn-ethanol was published in 1995, 2002, and 2003 in the American Society of Agricultural Engineers (ASAE), Shapouri et al. Since 1970, many authors have studied the net energy balance of corn-ethanol. The major objective of this report is to improve the general estimation procedure. These improvements include: (1) regular updating of the estimates based on the latest data on corn production and corn yield, (2) improving the quality of estimates for energy used in manufacturing and marketing nitrogen fertilizer, (3) improving the quality of estimates for energy used to produce seed-corn, and (4) enhancing the methodologies used in allocating the energy used in ethanol production (to byproducts and ethanol). In contrast to three previous studies, all energy inputs are reported in low-heat value (LHV).

During the past 2 years, David Pimentel, 2003, Tad Patzek, 2003, and Andrew Ferguson, 2003, criticized USDA's studies of the net energy balance of corn ethanol. It is argued that USDA underestimates energy used in the production of nitrogen fertilizer and the energy used to produce seed-corn, over estimating the energy allocated to produce corn-ethanol byproducts. They also argued that USDA excludes energy used in corn irrigation and secondary energy inputs used in the production of corn, such as farm machinery and equipment and cement, steel, and stainless steel, used in the construction of ethanol plants.

THE NET ENERGY BALANCE

This paper, unlike the Dr. Pimentel report, 2003, is based on straightforward methodology and highly regarded quality data from the 2001 Agricultural Resource Management Survey (ARMS), Economic Research Service, ERS/USDA, 2001 Agricultural Chemical Usage, and 2001 Crop Production, National Agricultural Statistics Service, NASS/USDA, and the 2001 survey of ethanol plants.

Direct energy used on farms, such as gasoline, diesel, LP gas (LPG), natural gas, and electricity, for the production of corn, including irrigation by States from 2001 ARMS, are available on the ERS Web site. The number of seed-corn planted per acre in 2001, custom work expenditure, tons of lime used per acre, and purchased water were also from the 2001 ARMS. Quantities of fertilizers and pesticides used per acre of corn in 2001 were published by NASS. Although corn is produced in every State, we focused our analysis on the major corn-producing States: Illinois, Indiana, Iowa, Minnesota, Nebraska, Ohio, Michigan, South Dakota, and Wisconsin. In 2001, these nine States accounted for 79 and 92 percent of U.S. corn and ethanol production, respectively.

Corn yield is a critical part of the net energy balance estimation. Although the corn yield has been rising over time, the annual variation is very volatile. Therefore, we used a 3-year average yield instead of the average yield for the survey year. The 2000-02 weighted average corn yield in each State was used to convert farm inputs from a per acre basis to a per bushel basis (2001 Crop Production, NASS). Table 1 shows the nine-State energy input data per acre of corn and nine-State weighted average for the 2001 ARMS.

Table 1--Energy-related inputs used to grow corn in nine States and nine-State weighted average, 2001

		IL	IN	IA	MN	NE	OH	MI	SD	WI	9-State Weighted average
Yield 2000-02 average	Bushels/acre	146.31	141.85	152.06	144.35	133.66	125.8	114.78	105.82	131.48	139.34
Seed	Kernels/acre	29158	28281	29855	30816	26619	28934	27867	25270	29860	28739
Fertilizer:											
Nitrogen	pounds/acre	154.53	147.33	125.04	113.74	131.73	168.3	125.52	109.09	106.6	133.52
Potash	pounds/acre	116.81	132.32	68.72	61.82	21.14	112	102.1	31.99	56.01	88.2
Phosphate	pounds/acre	80.88	67.28	57.32	46.31	35.18	67.39	50.06	45.54	37.43	56.81
Lime	pounds/acre	20	20	20	0	0	20	20	0	60	15.67
Energy:											
Diesel	Gallons/acre	3.7	4.6	4.6	5.4	12.4	4.3	7.2	4.4	7.4	6.85
Gasoline	Gallons/acre	1.5	2.1	1.2	1.7	2.1	1.6	2.5	1.5	1.4	3.4
LPG	Gallons/acre	2.8	3.2	7.2	8.5	4.1	5.6	3.6	0.5	1.9	3.42
Electricity	kWh/acre	9.6	28.3	16.8	26.8	152.5	10	25.5	27.4	6.6	33.59
Natural Gas	Cubic ft/acre	76.9	144.2	0	45.8	964	164	223.1	7	124	245.97
Custom work	Dol./acre	13.45	7.8	9.9	8.58	7.93	8.29	9.8	9.3	15.26	10.12
Chemicals	Pounds/acre	3.28	3.19	2.84	2	2.17	3.7	3.15	1.83	2.17	2.66
Purchased water	Dol./acre	0	0	0	0	1.2	0	0	0	0	0.18

Source: USDA, Economic Research Service and Office of Energy Policy and New Uses.

In previous studies, we assumed that energy used to produce seed-corn is equal to 1.5 times the energy used to produce corn. The review of literature and comments on our reports indicated that seed-corn production requires more energy because the seed-corn yield per acre is low and requires a considerable amount of electrical energy to process seed-corn including drying, shelling, grading, cleaning and storage. Based on an unpublished report prepared by Michael Graboski, 2002, for the National Corn Grower Association, the energy required for growing and processing seed-corn is estimated at 4.7 times that required for production of corn. The factor of 4.7 is used in this study.

The amount of energy used to produce a pound of nitrogen has been estimated in several studies. The values range from 18,392 Btu of high heat value (HHV) per pound, Shapouri et al, 2002, to over 33,590 Btu LHV per pound, Pimentel 2003. For this report, we asked Keith Stokes, President of the Stokes Engineering Company and fertilizer expert, to estimate the energy used in the production of nitrogen, phosphate, and potash fertilizers. His estimates of energy used (LHV) to make and deliver nutrients are 24,500 Btu per pound of N, 4,000 Btu per pound of P_2O_5, and 3,000 Btu per pound of K_20.

The energy used to produce herbicides and insecticides are from Wang et al.1999, the Greenhouse Gas Regulated Emissions and Energy Use in Transportation (GREET) model, Argonne National laboratory. More than 153,000 Btu of energy is required to produce a pound of herbicides, and about 158,000 Btu of energy is required to produce a pound of insecticides. A weighted average of over 154,000 Btu of energy is used per pound of pesticides. Farm-related energy inputs are converted per bushel and then to Btu of energy per bushel of corn by multiplying each input by its LHV. The energy required for hauling these inputs to farms, excluding fertilizer, was also estimated. The energy used to produce fertilizers includes energy used to deliver fertilizer to farm. The total energy requirements for farm inputs are given in Table 2.

The energy associated with transporting the corn from local storage facilities to ethanol plants was estimated by the GREET model. The average energy used for transporting a bushel of corn was 5,636 Btu or about 2,120 Btu per gallon of ethanol.

Ethanol production facilities include both dry- and wet-milling operations. Dry mills are usually smaller than wet mills and are built primarily to produce ethanol. Wet mills are bio-refineries and produce a wide range of products such as ethanol, high fructose corn syrup (HFCS), starch, food and feed additives, and vitamins. Thermal and electrical powers are the main types of energy used in both types of processing plants. Wet mills usually generate both electrical and thermal energy from burning natural gas or coal. Dry mills use natural gas to produce steam and purchase electricity from a utility.

The energy used to convert corn to ethanol is based on a U.S. survey conducted in 2001 by BBI International. On the average, dry mill ethanol plants used 1.09 Kwh of electricity and about 34,700 Btu of thermal energy (LHV) per gallon of ethanol. When energy losses to produce electricity and natural gas were taken into account, the average dry mill ethanol plant consumed about 47,116 Btu of primary energy per gallon of ethanol produced. Wet mill ethanol plants that participated in the survey used 49,208

Table 2--Total energy requirements of farm inputs for nine State and nine-State weighted average, 2001

	IL	IN	IA	MN	NE	OH	MI	SD	WI	9-State Weighted average
					BTU/bushel					
Seed	525	557	451	512	804	780	827	623	548	603
Fertilizer:										
Nitrogen	25876	25446	20147	19305	24146	32764	26792	25257	19864	23477
Potash	2395	2798	1356	1285	474	2670	2669	907	1278	1899
Phosphate	2211	1897	1508	1283	1053	2142	1745	1721	1139	1631
Lime	76	79	73	0	0	89	97	0	255	63
Energy:										
Diesel	3853	4941	4609	5700	14136	5207	9558	6336	8576	7491
Gasoline	1478	2135	1138	1698	2266	1834	3141	2044	1536	3519
LPG	1644	1938	4067	5058	2635	3823	2694	406	1241	2108
Electricity	614	1868	1035	1739	10685	744	2081	2425	470	2258
Natural Gas	550	1063	0	332	7544	1363	2033	69	986	1846
Custom work	2001	1197	1417	1294	1291	1434	1859	1913	2526	1581
Chemicals	3453	3464	2877	2134	2501	4530	4227	2664	2542	2941
Purchased water	0	0	0	0	946	0	0	0	0	136
Input hauling	143	167	178	176	242	209	254	121	251	202
Total	44821	47551	38856	40516	68723	57590	57977	44486	41212	49753

Btu per gallon of natural gas and coal, on average, to produce steam and electricity in the plants. After adjustments for energy losses to produce natural gas and coal, on the average, a wet mill ethanol plant used 52,349 Btu of energy to make a gallon of ethanol.

The average energy associated with the transport of ethanol from ethanol plants to refueling stations was estimated by the GREET model. The average energy used for transporting a gallon of ethanol was 1,487 Btu per gallon for both dry and wet milling.

The production of ethanol comes with a range of byproducts, such as distillers dried grains with soluble (DDGS) in the dry milling operation, and corn gluten feed (CGF), corn gluten meal (CGM), and corn oil in the wet milling process. The energy used to produce corn and convert corn to ethanol, including hauling corn from farms or grain elevators to ethanol plants, should be allocated to ethanol and byproducts.

In the previous studies, we used a replacement method to allocate total energy to ethanol and byproducts. For this report, we used ASPEN Plus, a process simulation program, to allocate the energy used in the plants to ethanol and byproducts. On the average, 59 and 64 percent of the energy used to convert corn to ethanol is allocated to ethanol in dry- and wet-mills respectively.

Energy is used to produce and transport corn to ethanol plants allocated to starch and other corn kernel components, such as fiber, germ, and protein. Only starch is converted to ethanol. On the average, starch accounts for 66 percent of the corn kernel weight (15 percent moisture). Therefore, 66 percent of energy used to produce and transport corn to ethanol plants is allocated to ethanol and 34 percent to byproducts.

Energy used in the production of secondary inputs, such as farm machinery and equipment used in corn production, and cement, steel, and stainless steel used in the construction of ethanol plants, are not included in our study. Available information in this area is old and outdated. Pimentel, in his latest report (2003), used the 1979 Slesser and Lewis to estimate the energy used in the production of steel, stainless steel, and cement.

RESULTS

All energy inputs used in the production of ethanol is adjusted for energy efficiencies developed by GREET model. The estimated energy efficiencies are for gasoline (80.5 percent), diesel fuel (84.3 percent), LPG (98.9 percent), natural gas (94 percent), coal (98 percent), electricity (39.6 percent), and transmission loss (1.087 percent). After adjusting the energy inputs by these energy efficiencies, the total estimated energy required to produce a bushel of corn in 2001 was 49,753 Btu.

Table 3 summarizes the input energy requirements, by phase of ethanol production on a Btu per gallon basis (LHV) for 2001, without byproduct credits. Energy estimates are provided for both dry- and wet-milling as well as industry average. In each case, corn ethanol has a positive energy balance, even before subtracting the energy allocated to byproducts.

Table 4 presents the final net energy balance of corn ethanol adjusted for byproducts. The net energy balance estimate for corn ethanol produced from wet-milling is 27,729 Btu per gallon, the net energy balance estimate for dry-milling is 33,196 Btu per gallon, and the weighted average is 30,528 Btu per gallon. The energy ratio is 1.57 and 1.77 for wet- and dry-milling, respectively, and the weighted average energy ratio is 1.67.

Table 3--Energy use and net energy value per gallon without coproduct energy credits, 2001

	Milling process		Weighted
Production process	Dry	Wet	average
	Btu per gallon		
Corn production	18875	18551	18713
Corn transport	2138	2101	2120
Ethanol conversion	47116	52349	49733
ethanol distribution	1487	1487	1487
Total energy used	69616	74488	72052
Net energy value	6714	1842	4278
Energy ratio	1.10	1.02	1.06

Table 4--Energy use and net energy value per gallon with coproduct energy credits, 2001

	Milling process		Weigted
Production process	Dry	Wet	average
	Btu per gallon		
Corn production	12457	12244	12350
Corn transport	1411	1387	1399
Ethanol conversion	27799	33503	30586
ethanol distribution	1467	1467	1467
Total energy used	43134	48601	45802
Net energy value	33196	27729	30528
Energy ratio	1.77	1.57	1.67

REFERENCES

Ferguson, A. 2003. *Implication of the USDA 2002 Update on Ethanol from Corn.*Vol.3, No 1. Manchester, UK.: The Optimum Population Trust.
Graboski, Michael. 2002. *Fossil Energy Use in the Manufacturing of Corn Ethanol.* Denver, CO.: Colorado School of Mines.
Patzek, Tad. & CE24 Freshman Seminar Students. 2003. *Ethanol from Corn: Clean Renewable Fuel for the Future, or Drain on our Resources and Pockets? Vol. 12, No. 2,* Netherlands.: *Natural Resources Research,* Kluwer Academic Publishers.

Pimentel, David. 2003. *Ethanol Fuel: Energy Balance, Economics, and Environmental Impacts are Negative*. Vol.12, No.2.: 2003 International Association for Mathematical Geology, Natural Resources Research,
Shapouri, H., J.A. Duffield, and M. Wang. 2003.*The Energy Balance of Corn Ethanol Revisited.*: 2003 American Society of Agricultural Engineers, Vol.46 (4): 959-968.
Shapouri, H., J.A. Duffield, and M. Wang. 2002.*The Energy Balance of Corn Ethanol: An Update*. AER-814. Washington, D.C.: USDA Office of the Chief Economist.
Shapouri, H., J.A. Duffield, and M.S. Graboski. 1995. *Estimating the Net Energy Balance of Corn Ethanol*. AER-721. Washington, D.C.: USDA Economic Research Service.
Stokes, Keith. *2004. Estimate of Energy Used to Make and Deliver N, P, and K Fertilizer to the Farm Gate*. Weston, CT.: 2004 Special Reports for the USDA/OCE, Stokes Engineering Company.
USDA-ERS. 2001. *Commodity Costs and Returns, Energy Use on Major Field Crops in Surveyed States.* Washington, D.C.: *USDA Economic Research Service.* www.ers.usda.gov/Data/CostsAndReturns/testpick.htm.
USDA-NASS. 2001. *Agricultural Chemical Usage, 2001 field Crops Summary.* Washington, DC.: USDA National Agricultural Statistics Service.
USDA-NASS. 2001. *Field Crops 2001 Crop Production.* Washington, DC.: USDA National Agricultural Statistics Service.
Wang, M., C. Saricks, and D. Santini. 1999. *Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions*. Argonne, IL.: USDOE Argonne National laboratory, Center for Transportation Research.

OIL SLICKERS:
HOW PETROLEUM BENEFITS AT THE TAXPAYER'S EXPENSE

Jenny B. Wahl, Ph.D.

August 1996

INSTITUTE FOR LOCAL SELF-RELIANCE

Related Publications Available From ILSR

How Much Energy Does It Take To Make A Gallon Of Ethanol, by David Morris and David Lorenz July 1995

Restructuring Minnesota's Tax System: Taxing Pollution Rather Than Work And Investment, by David Morris February 1995

Taxing Wind Energy In Minnesota, by John Bailey and David Morris January 1995

How Much Energy Does It Take To Make A Gallon Of SoyDiesel, by David Morris, John Decker and Irshad Ahmed January 1994

Making The Car Pay Its Way: The Case Of Minneapolis Roads, by John Bailey December 1992

The Institute for Local Self-Reliance (ILSR) is a non-profit research and educational organization that provides technical assistance and information on environmentally sound economic development strategies. Since 1974, ILSR has worked with citizen groups, government and private businesses to develop policies that extract the maximum value from local resources.

Institute for Local Self-Reliance

1313 5th Street SE, Suite 306
Minneapolis, MN 55414
Phone: (612) 379-3815
Fax: (612) 379-3920

2425 18th Street NW
Washington, DC 20009
Phone: (202) 232-4108
Fax: (202) 332-0463

Web Site: http://www.ilsr.org

A Word from ILSR

Market economies work best when they rely on accurate prices. Yet many of the prices we pay do not reflect the full costs of producing, using and disposing the goods we consume. The most important example of this mismatch may occur in the transportation sector.

For 22 years ILSR has worked to build strong and environmentally sound economies. One practical tool for moving us in this direction is to get the prices right. It is in that spirit that we offer this study.

The United States has by far the lowest gasoline prices among industrialized countries, and the few brave politicians who have tried to raise gas taxes quickly felt the anger of their constituents. Yet the price we pay at the pump for gasoline and diesel bears little relationship to the real cost of driving.

This is true even in the narrowest sense. Many of us believe our transportation system is a pay-as-you go proposition, that motor vehicle fees and gas taxes fully cover the cost of the roads upon which we drive. But as John Bailey points out in his well-documented ILSR report, *Making the Car Pay Its Way*, the costs of maintaining local roads in Minneapolis largely comes not from transportation taxes but from property taxes. If we were to shift this burden onto drivers and off of property owners, motorists would have to pay 18 cents more a gallon.

Many other quantifiable costs are unaccounted for in the price we pay at the pump. To determine these costs, the Institute for Local Self-Reliance asked Dr. Jenny Wahl to review the existing literature on the subject. Dr. Wahl is a most fitting person to undertake this task. She is one of the nation's eminent tax analysts and economists. An Associate Professor of Economics at Saint Olaf College in Northfield, Minnesota, Dr. Wahl has worked in the U.S. Treasury Department's Office of Tax Analysis and is a member of the Star Tribune's Board of Economists.

Dr. Wahl's conclusion—that if we eliminated the tax, environmental and military subsidies for gasoline, the price at the pump could rise by 32 cents a gallon—we think is not only defensible but very conservative. For example, this report gives very little weight to the potential costs of global warming.

Based on this study, Minnesotans subsidize the oil industry by over $700 million a year. These subsidies have the perverse effect of artificially lowering the price of gasoline. This encourages driving and increases pollution while slowing the development of alternatives such as more efficient vehicles or non-petroleum fuels.

Dr. David Morris
Vice President

OIL SLICKERS:
HOW PETROLEUM BENEFITS AT THE TAXPAYER'S EXPENSE

Jenny B. Wahl, Ph.D.

EXECUTIVE SUMMARY

How much does gasoline cost? A lot more than what you pay at the pump. If you include the tax subsidies, the costs to taxpayers of protecting oil supplies, and the costs of environmental and health hazards, a gallon of gas costs about 32 cents more than its pump price.

The national costs of petroleum unaccounted for in its retail price — its external costs — range from $42 billion to nearly $350 billion per year. The costs to Minnesotans range from $469 million to $2.95 billion per year. Transalted into cents per gallon, gasoline receives subsidies that range from 21 cents to $1.34 per gallon. Tax subsidies received by the petroleum industry are the easiest to measure and account for $3.3 billion to $10.9 billion of this total. The largest single cost element encompasses the military costs of protecting our oil supplies, which range from $26.6 billion to $70.7 billion. The hardest cost element to quantify, but also potentially the most important, is the environmental and health costs associated with pollution and global warming. Estimates of these costs range from $25.5 billion to $267 billion per year.

This report concludes that a reasonable and still conservative estimate of the external costs of gasoline is 32 cents per gallon or $84 billion per year. This estimate assumes a very low external environmental and health cost.

OIL SLICKERS:
HOW PETROLEUM BENEFITS AT THE TAXPAYER'S EXPENSE

Jenny B. Wahl, Ph.D.
August 1996

We are not going to solve our transportation-related security, climate, pollution, and congestion problems without a serious effort to internal ize the costs now generated by motor vehicle drivers.
—James MacKenzie, World Resources Institute[1]

Suppose you ran a business. You'd pay to protect your property – salaries for security guards, the cost of fences, insurance premiums, and the like. You would also expect to pay — either through a private contract or in court —for damages you might inflict on others. If, say, the fumes from your auto-repair shop blew into the restaurant next door, you'd likely pay your neighbor something for their losses.[2] And you wouldn't expect to receive tax breaks any greater than the other businesses in the neighborhood.

None of this is true for the petroleum industry. It can count on the U.S. military to defend its interests abroad, and it depends on taxpayers to finance strategic petroleum reserves at home should overseas supplies be disrupted. Despite what oil and gas does to our health and environment, the petroleum industry bears few costs associated with these ills, either. What is more, the U.S. tax system gives out among its most handsome subsidies to oil and gas interests.[3] As a result, the prices of oil products are artificially lower than they otherwise would be.

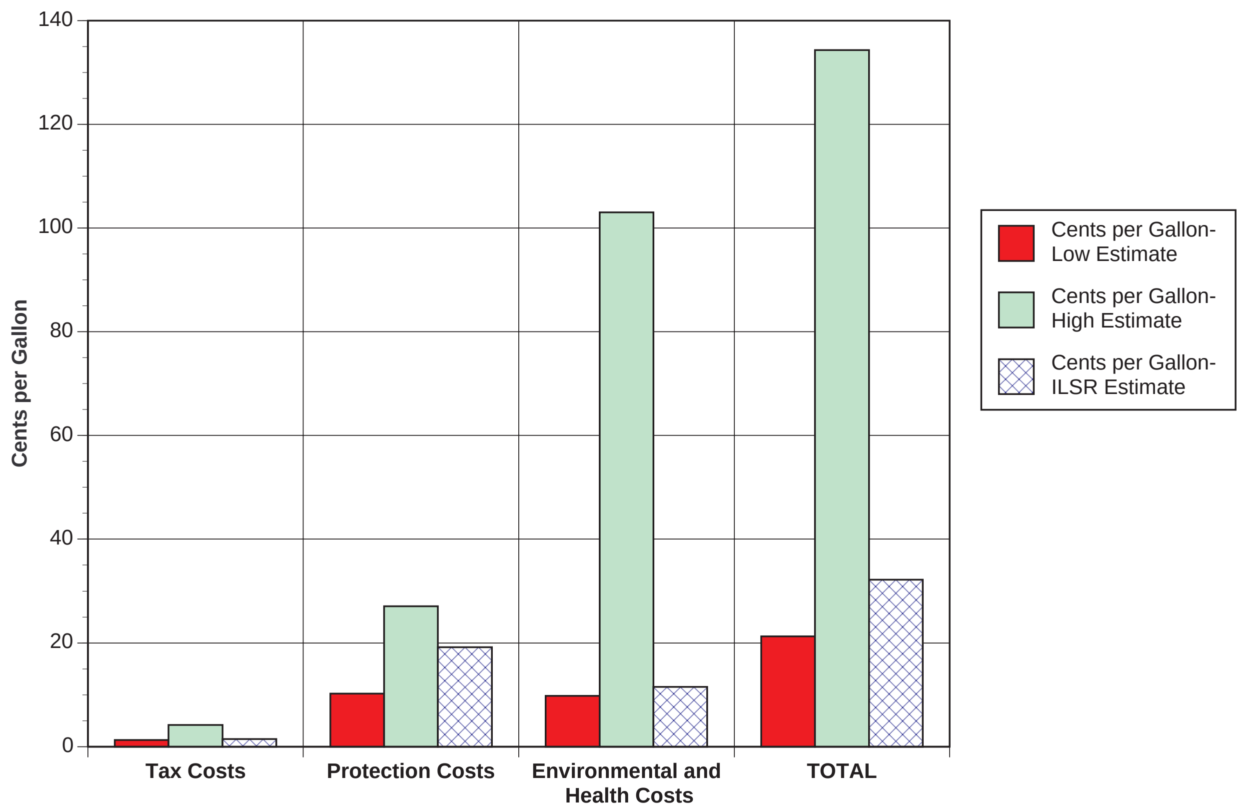
What is the true cost of gasoline? Much more than what you pay at the pump. A gallon of regular unleaded costs about $1.30, but about 37 cents of that is state and federal taxes primarily used to pay for transportation-related expenses like road construction and maintenance.[4] If motorists had to pay the true cost of gasoline, the pump price would be much higher.

Many experts have tried to quantify the external costs of oil. In this report, ILSR reviews dozens of existing studies and develops a range of estimates and a single best guess-number. The three key types of external costs are preferential tax treatment; the cost of protecting oil supplies; and the environmental and health costs associated with burning oil.[5] The methodology used in this report is to identify key studies, to extract from them a range of estimates of the external cost of petroleum and to translate that number into cents per gallon of gasoline. Tables 3, 4, and 5 break down the costs by category and element. Tables 1 and 2 summarize the results of these tables. Based on the studies reviewed, our best-guess estimate of the subsidies received by petroleum each year is $84 billion. This figure of 32 cents per gallon, we believe is very conservative. Figure 1 presents the low and high external cost estimates and the ILSR estimate. With regard to the tax costs, the ILSR estimate is very close to the lowest bound of the range. This is also true of the ILSR estimate of environmental and health costs, where the ILSR estimate is less than 20 percent above the low cost estimate. The ILSR estimate for military subsidies to oil is in the higher range because most of the studies of these costs clustered at this level. This translates into about 32 cents per gallon of gasoline.[6] For Minnesota, which uses about 2.2 billion gallons of gasoline per year, this external cost represents about $704 million.

TABLE 1
The Range of External Costs of Petroleum

	U.S. Total Cost (cents per gallon)	ILSR Estimate (cents per gallon)
Tax Costs	1.3 - 4.2	1.5
Protection Costs	10.2 - 27.1	19.2
Environmental and Health Costs	9.8 - 103.0	11.5
TOTAL	**21.3 - 134.3**	**32.2**

Figure 1: The External Cost of Gasoline (cents per gallon)



Note: These numbers allocate the external costs of the 261 billion gallons of petroleum annually consumed in the U.S. across all uses.

One comment about the applicability of these estimates to Minnesota: the figures presented in this report are national averages. Despite what Garrison Keillor says, Minnesotans in fact are average in many respects – adult population, income, federal income tax payments, number of vehicles, and gas taxes. The state boasts 1.74 percent of the population aged 18 and older, it reports 1.85 percent of income earned by individuals, it pays 1.8 percent of federal taxes.[7] Its citizens own 1.97 percent of passenger cars (about 3 million) and 1.69 percent of buses and trucks (nearly a million).[8] Minnesotans pay median federal and excise tax rates on gasoline.[9] In one key respect, however, we differ from some states – we import virtually all of our petroleum.

TABLE 2
The Range of External Costs of Petroleum

	U.S. Total Cost (billion $)	U.S. Cost ILSR Estimate (billion $)	Minnesota Cost (million $)	Minnesota Cost ILSR Estimate (million $)
Tax Costs	3.3 - 10.9	3.7	28.6 - 92.4	32
Protection Costs	26.6 - 70.7	50	224.4 - 596.2	419
Environmental and Health Costs	25.5 - 267	30	215.6 - 2,266	253
TOTAL	**55.4 - 348.6**	**83.7**	**468.6 - 2,954**	**704**

TAX PREFERENCES

One way that Americans subsidize the petroleum industry is through the tax code. The Treasury Department and the Joint Committee on Taxation track these sorts of subsidies but, naturally, view them in terms of losses to government coffers. Yet the two concepts are simply reverse sides of the same coin — a lower tax due to preferential treatment is the equivalent of a subsidy.[10] Moreover, lower taxes for one set of taxpayers mean higher taxes for the rest of us.[11] One means of expressing the degree of tax preference enjoyed by an industry is to calculate its effective tax rate.

Jane Gravelle of the Congressional Research Service found an effective tax rate on oil and gas extraction income of 11 percent, as compared to the statutory rate of 35 percent. Other industries have effective tax rates much closer to the statutory rate.[12]

The official term used to describe a taxpayer subsidy is a "tax expenditure." As the Joint Committee on Taxation puts it, tax expenditures are "decreases in . . . tax liabilities that result from provisions in income tax laws and regulations that have been enacted to provide economic incentives . . . or tax relief . . ."[13] The petroleum industry enjoys a variety of these provisions, despite recommendations (official and otherwise) to end them.[14] Petroleum producers are currently requesting even greater tax relief, including tax credits for oil produced from existing stripper wells and from deep water.[15]

All told, Americans will give up $3.3 billion to $10.9 billion in tax revenues in 1996 because of tax preferences enjoyed by the petroleum industry.[16] Table 3 summarizes the various annual tax subsidies that petroleum receives.

TABLE 3
Annual Tax Subsidies to Petroleum

Federal Tax Categories	Amount (million $)
Percentage depletion	985.0
Alternative fuel production	756.0
Expensing of exploration and development	140-275
Enhanced recovery	97.0
Deferral of income from controlled foreign	180-286
Foreign tax credit (in contrast to deduction)	777-3,380
Accelerated depreciation	113-4,438
Research and experimentation	114.0
Working capital exception to passive loss limitation	60.0
Alaska native corporations	0-15
Exclusion of interest on municipal bonds	0-180
TOTAL	**3,222-10,586**
TOTAL adjusted for state taxes	**3,319-10,904**

Percentage depletion method One of the largest tax subsidies enjoyed by petroleum producers is a provision that allows them to deduct a percentage of gross income to account for depletion of oil reserves.[17] Most taxpayers are entitled to deductions that correspond to the costs of doing business, but the percentage depletion deduction bears no resemblance to the costs actually incurred by oil and gas producers. In fact, producers can continue to claim percentage depletion long after all expenses incurred to acquire or develop a property have been recovered. The size of this subsidy is $985 million for 1996.

The percentage depletion method has been with us since nearly the beginning of the income tax. The allowable rate was set at 27.5 percent in 1926, finally reduced to 22 percent in 1969. The Tax Reduction Act of 1975 repealed the deduction for major oil companies, and later acts reduced the rate to 15 percent and restricted the use of the deduction. Yet recent tax law has gone the other way. Because of national security concerns, in 1989 the cap on the allowable deductible amount increased from 50 percent to 100 percent of net income. The 1990 Act expanded the use of percentage depletion to transferred property. And the Energy Policy Act of 1992 provided that excess percentage depletion deductions related to oil and gas production are not items of tax preference for purposes of the alternative minimum tax for taxable years beginning after 1992.

Alternative (nonconventional) fuel production credit A second large subsidy given to petroleum producers is a tax credit of $3 per barrel-of-oil-equivalent for fuels produced by non-conventional means.[18] This credit applies, for example, to oil produced from shale and tar sands and gas produced from geopressured brine, Devonian shale, coal seams, or biomass. The petroleum industry is not the only one to benefit from this credit, but it captured 72 percent of the total in 1991 and 76 percent in 1992.[19] Texaco took enough alternative fuel production credits to reduce its tax bill by $29.3 million in 1994.[20] The overall tax subsidy to petroleum interests attributable to this preference item will be about $756 million in 1996. According to one Treasury official, this subsidy is fast becoming more important as producers look for deposits of oil in hard-to-reach places.

Expensing of exploration and development costs A tenet of good tax policy is to match costs and benefits appropriately. In general, costs that yield future benefits must be capitalized and recovered over that future period for tax purposes. But oil and gas producers can instead expense certain exploration and development expenditures – that is, take an immediate tax deduction – regardless of how long these investments might be expected to generate future income.[21] In 1996, this subsidy cost us $140 million; in recent years, the subsidy has run as high as $275 million.[22] Recent Tax Court decisions have tended to favor the taxpayer – permitting larger deductions and thus greater subsidies to the petroleum industry.[23]

Enhanced oil recovery credit Yet another tax benefit enjoyed by the petroleum industry is the ability to take a tax credit for the costs of certain methods designed to enhance the process of recovering oil.[24] Such methods include injecting chemicals into wells. The Treasury Department estimates this subsidy at $100 million for 1997; this amount translates to about $97 million in 1996 dollars.

Foreign tax provisions U.S. companies are taxed on their worldwide income but entitled to a credit for taxes paid to other governments, with some restrictions.[25] This “foreign tax credit” is intended to prevent double taxation and to harmonize domestic tax policy with the realities of multinational business operations. For the most part, the credit works reasonably well to ensure that U.S. companies pay the same (or greater) tax on income earned abroad as on income earned at home. In two major areas, however, the tax code can be manipulated: when U.S. companies establish subsidiaries overseas and can time the repatriation of dividends, and when foreign governments and U.S. multinationals conspire to call something a tax when it is not. All sorts of industries may benefit from the former; the petroleum industry may particularly gain from the latter practice.

Income earned through controlled foreign corporations is not taxed in the U.S. until it returns home as dividends.[26] Tax subsidies arising from income deferral will total $1.8 billion in 1996 for all industries. Of the largest 7,500 such corporations, between 10 and 15.9 percent were associated with oil and gas interests in 1992.[27] Estimated subsidies arising from deferral of income therefore range from $180 million to $286 million for the petroleum industry in 1996.

Tax subsidies for petroleum associated with the foreign tax credit are even larger. In 1992, petroleum companies took about $5.2 billion in foreign tax credits.[28] Because many oil-producing countries have no business tax (particularly in the Persian Gulf), some of the amounts claimed as foreign taxes were actually royalty payments in disguise, akin to the royalties and severance taxes that oil and gas companies pay to states like Alaska and Texas. As a result, a recent Senate bill proposed disallowing foreign tax credits for any oil and gas extraction income from anywhere for multi-national corporations. The Administration proposed a milder version suggesting that credits be denied for income received in countries that have no effective corporate tax. Both proposals have quietly disappeared.[29] If the petroleum industry could only deduct foreign taxes instead of taking a credit for them, we could raise an additional $3.38 billion in revenue in 1996. If such a provision applied only to income from countries with no income tax, we could raise about $777 million. But the failure of the Senate and Administration proposals, coupled with major defeats for the Internal Revenue Service in the Tax Court, indicate that these subsidies are firmly entrenched.[30]

Accelerated depreciation allowances Most U.S. taxpayers know that they can take depreciation deductions on business assets – deductions based on asset cost that correspond to the reduction in value of the asset due to wear and tear or obsolescence. Most of us also know that we can take bigger deductions in the first years after we buy a business asset. That is, we can accelerate depreciation for tax purposes and therefore enjoy lower tax bills earlier on. By comparison with straight-line depreciation (which would entitle us to equal tax deductions each year over the life of the asset), we can keep our money longer and thus gain a tax benefit.

For all industries, the estimated tax expenditure associated with accelerated depreciation totals nearly $24 billion for 1996 and over $35 billion for 1997.[31] Yet these large numbers overestimate the true amount of tax subsidies enjoyed by asset holders. Accelerated depreciation is designed in part to counteract the effects of inflation. For good accounting reasons, people must base depreciation deductions on the purchase price of an asset. In times of inflation, however, the prices of most assets (and therefore their replacement costs) increase over time. Straight-line depreciation thus underestimates the annualized cost associated with a depreciable asset when inflation is present. But we have had relatively lower inflation in the past few years than during the period in which the tax authorities crafted the accelerated depreciation rules. Some portion of the tax expenditure currently attributable to accelerated depreciation should therefore be considered a taxpayer subsidy.

How much of the estimated tax expenditure on accelerated depreciation represents a taxpayer subsidy for petroleum? Corporate tax return data indicate that the petroleum industry accounts for about 4.7 to 4.8 percent of depreciation deductions and about 12.6 percent of depreciable assets.[32] An upper bound on the subsidy to petroleum from this tax provision could look to the 1997 tax expenditure data and include the entire (pro-rated) amount – nearly $4.5 billion. If, say, only 10 percent of the 1996 tax expenditure amount were counted, a lower bound for the figure would be about $113 million.

Expiring provisions: research and experimentation, exception from passive loss limitation for working capital Two features of the tax code that pertain to taxpayer subsidies to petroleum have expired, but the presence of transition rules means that subsidies in these two areas still exist for the next several years. The first feature is favorable tax treatment for research and experimentation costs, which expired in July 1995. Certain incentives will be phased out over a period of years, creating an estimated $2.4 billion in tax expenditures for 1996 and $10.9 billion for 1996-2000 across all industries. The portion attributable to the petroleum industry is approximately $114 million for 1996. A second expired provision that pertains solely to the oil and gas industry is an exception to the passive loss limitation for working capital – resulting from a complicated interaction of tax regulations. This exception was repealed in 1993 but will still cost $60 million in 1996 and $320 million over the period 1996 to 2000.

Other relevant federal subsidies Two additional tax expenditure items may generate subsidies to the petroleum industry: the treatment of Alaska native corporations and the exclusion of interest on industrial development bonds. Businesses run by Alaskan natives receive favorable tax treatment to the tune of about $15 million annually. Although these companies have not necessarily been associated with petroleum, natives have recently agitated for a share of Alaska royalty oil to set up some petroleum interests. The exclusion of interest on state and local industrial development bonds for energy facilities will create a tax expenditure of about $180 million in 1996. Not all of this amount can be attributed to petroleum, but some fraction can.

To calculate subsidies to the petroleum industry generated by special tax or financial treatment, two other items deserve mention. The United States has existing or proposed tax treaties with a number of oil-producing countries, including Egypt, Indonesia, Mexico, Russia, and Kazakhstan. To the extent that treaties might reduce statutory tax rates or grant favorable treatment for certain types of income, petroleum interests may benefit beyond the confines of the existing tax code and regulations.

Besides the possibility of benefiting from tax incentives and tax treaties, oil companies are lining up with multibillion dollar projects at the doors of the Overseas Private Investment Corporation (OPIC). Essentially, those companies with OPIC status are insured with taxpayer dollars against adverse changes in the host country's political conditions. Recently, OPIC administrators approved loan guarantees and insurance worth $28 million to Texaco to establish a Russian facility. Conoco implemented a similar project at about the same time.[33] OPIC companies have been set up to foster economic development in certain regions, particularly the Soviet Union – a laudable goal, perhaps. But OPIC companies also mean that, if a company loses all or part of its investment due to unrest abroad, U.S. taxpayers will foot the bill.

Interaction of state and federal tax calculations Because most states piggyback off federal tax returns to calculate state taxable income, industries that benefit from favorable federal tax deductions also benefit at the state level. (Federal tax credits do not generate similar piggyback effects.) State corporate tax rates vary widely but average about 5 percent. A conservative accounting for the interaction of state and federal taxes would augment total federal subsidies by about 3 percent.[34]

Conclusion The total tax subsidies related to petroleum are $3.3 billion to $10.9 billion. Per gallon of gasoline, this comes to 1.3 cents to 4.2 cents per gallon. We believe that 1.45 cents per gallon is a conservative and reasonable estimate.

EXPENDITURES DESIGNED TO PROTECT OIL SUPPLIES

Currently, the United States imports 1.4 million barrels of oil a day from Persian Gulf countries; one-quarter of the world's oil supply comes from the region.[35] Even more telling, two-thirds of the known oil reserves lie in the Gulf – the largest supplies in Saudi Arabia, the next-largest in Iraq.[36] Much of the rest of the world's petroleum supply comes from other potentially politically unstable countries.

Given our dependence on the continuing supply of foreign oil, we have undertaken a number of measures designed to insulate ourselves against disruption.[37] Most notably, the U.S. maintains a military presence – which it is willing to use in combat — in oil-sensitive areas. We also maintain a large reserve of crude oil in tanks around the country. In addition, we devote Department of Energy funds to petroleum research.

All of these programs come at taxpayer expense at a cost of $26.6 billion to $70.7 billion per year, with a greater probability attached to the high end of the range.[38] Table 4 details the various costs associated with protecting petroleum.

TABLE 4
Annual Costs of Protecting Petroleum Resources

	Amount (million $)
Routine Maintenance of Troops and Equipment	25,200-63,000
Annualized Cost of Combat	300-6,300
Petroleum Reserve-Routine Maintenance	201
Petroleum Reserve-Annualized Cost of Moving	5-10
Foregone Use of Funds	724-1,035
R & D Costs	180
TOTAL	**26,610-70,726**

<u>Routine maintenance of military forces</u> In 1996, the total requested funding for military operations by the Defense Department is $252 billion.[39] How much is devoted to protecting petroleum? Hard to say. Even without the presence of oil, some troops might be stationed in oil-rich areas for other reasons. What is more, troops can be mobilized worldwide if necessary. Knowing the number of soldiers present in a given region does not necessarily tell us what we would like to know: the incremental cost of maintaining and equipping military personnel solely because we want to protect oil supplies. Direct calculation of such a cost is virtually impossible.

Indirect calculation is, however, possible. According to a former Assistant Secretary of Defense for Economic Security, we currently have about 17,000 troops in the Persian Gulf.[40] This represents just over 1 percent of military personnel; the same percentage in budgetary terms is about $2.8 billion annually. By comparison, 42 percent (about 660,000 troops) served in the Gulf during the Desert Storm Operation.[41] In February 1991, the Congressional Budget Office estimated the annual (post-war) cost of stationing on-shore active forces in the Persian Gulf at $3.89 billion.[42] Of course, we maintain off-shore forces, troops in other oil-sensitive areas, and administrative personnel as well. Plausible estimates of the annual expense devoted to routine protection of oil resources might therefore range from 10 to 25 percent of the annual military budget — $25.2 to $63 billion.

Most researchers have estimated annual expenses toward the high end of this range. In a comprehensive survey of the literature on the subject, the Congressional Research Service found that analysts' estimates ranged from about $56 billion to $73 billion (in current dollars) annually devoted to defense of the Middle East/Persian Gulf.[43] Many experts have estimated the security costs of protecting petroleum at $50 billion or more per year.[44]

The cost of combat In addition to routine maintenance of troops near oil-rich areas, we have fought bloody battles – Desert Storm and Desert Shield are only the most recent. Estimates of the incremental cost of those conflicts vary, ranging from $57 billion to over $100 billion.[45] Our allies paid some of the cost – commitments are about $54 billion, but actual collections are more like $37 billion. The total costs of this war to U.S. taxpayers were therefore $3 billion to $63 billion. Naturally, none of these figures count the costs of pain and suffering to U.S. soldiers, nor costs to our adversaries.

We don't fight such wars every year. One Defense Department official speculated that the Gulf War might keep things quiet for up to 10 years.[46] At that rate, the annualized cost to U.S. taxpayers of combat to protect petroleum ranges from $300 million to $6.3 billion

Petroleum reserves The bulk of U.S. oil reserves – about 575 million barrels as of August 1, 1996 — resides in the Strategic Petroleum Reserve. The cost of maintaining the reserve is about 35 cents per barrel per year – over $200 million annually.[47]

Not only do taxpayers pay to maintain the reserve, they currently face a $100 million tab for decommissioning and moving part of it because of water intrusion and contamination. In all likelihood, other such moves will be necessary later on. Assuming that similar moves might take place every 10 to 20 years, the annualized cost would fall between $5 million and $10 million.

Yet a third – and much larger – cost to taxpayers is the foregone interest on the value of the reserves. Because we have billions of dollars tied up in barrels of oil rather than ready for use, we are giving up between $724 million and $1,035 million per year. Some of this loss could be offset if oil increased in value; over the life of the reserve, the value of petroleum has actually fallen.[48]

In addition to the Strategic Petroleum Reserve, we have Naval Petroleum Reserves. These Reserves were instituted to help the Navy convert from coal to oil. The budget request for 1996 to maintain the reserve is $208 million. Because public law has already authorized the sale of these reserves, (and because the oil produced there has been sold competitively on the open market), it is not included as a cost to taxpayers.

Research and development expenses The Department of Energy receives funding for research in fossil energy. In 1996, $180 million will be devoted solely to petroleum R & D.[49]

Conclusion The total costs for protecting our access to oil is $26.6 billion to $70.7 billion. Given the number of respected analysts who have concluded that the figure is around $50 billion, we have used that as our best-guess estimate. This translates into 19.2 cents per gallon.

ENVIRONMENTAL AND HEALTH COSTS

Petroleum products cause a variety of environmental and health damages, most of which go unreimbursed. These external costs are among the most difficult to quantity and estimates of the size of damages vary considerably. Calculations of environmental costs are also complicated by the varying methodologies used by analysts. For example, some calculate the damages caused by using oil; others calculate the costs of reducing or avoiding pollution. As Table 5 shows, estimates for the total external environmental and health costs associated with petroleum range from $25.5 billion to $267 billion in current dollars.

TABLE 5
Annual External Environmental and Health Costs of Petroleum

	Amount (million $)
Groundwater, Soil, and Air Pollution	24,867-240,333
Costs Associated With Global Warming	633-26,667
TOTAL	**25,550-267,000**

Environmental effects from within-border spills and leaky tanks Accidental (and sometimes deliberate) oil and gas spills pollute our surroundings. As one home-grown illustration, Lake Superior suffered an estimated 36 spills in 1994, consisting of a total of more than 11,000 gallons of fuel oil.[50]

Perhaps more ominous than spills are the 2.5 million underground and 250,000 above-ground storage tanks scattered around the country, filled mostly with petroleum products.[51] Thousands of these tanks have sprung leaks; the Environmental Protection Agency has estimated that more than 25 percent may be leaking or will leak within the next 3 to 5 years.[52] Cleanup is costly: the state of Texas has estimated its cost of cleaning up leaky underground storage tanks (cleverly termed LUSTs) at $2.5 billion, for instance. California has at least 30,000 known USTs; environmental lawyers working in the private sector estimate that half of their practice deals with oil and gas UST issues.[53] In one horrific 1988 incident, over 700 thousand gallons of diesel fuel spewed into Pennsylvania's Monongahela River from a collapsed storage tank.

Minnesota has its share of problems, with over 70 tank farms and some large refineries located within the state. In March 1994, for example, a leaky tank at Ashland Petroleum's St. Paul Park facility released upwards of 130,000 gallons of gasoline into the groundwater. In May of the same year, 1,500 gallons of oil leaked into the Mississippi River. As much as 2 million gallons of petroleum products are estimated to have accumulated on the water table over the last 50 years at the St. Paul Park site.[54]

How do we pay for this mess? In part, with a battery of fees and fines. In the past, we have designed some liability-based excise taxes in attempts to include these social costs in the final prices of petroleum and other potentially hazardous products. At the federal level, these have included Superfund, LUST, and oil spill taxes. These taxes are no longer being collected, although balances exist in each fund.[55] Moreover, a good part of the funds goes toward assessment studies, research, and lawyer fees rather than restoration.[56] And the funds devoted to contaminated sites pay only for costs of cleanup, not damages manifested by lower crop yields, medical bills, and the like. Superfund does not even apply to petroleum products – benzene, a known carcinogen, will not qualify contaminated gasoline stations as Superfund sites.[57]

Minnesota has certain fees and taxes in place devoted to dealing with petroleum contamination. The state charges an inspection fee of 85 cents per thousand gallons of petroleum products. We also have a LUST charge of 2 cents per gallon of petroleum products received in the state, subject to a cap on total collections; this tax is on a 4-month cycle and is not currently being collected. We impose fines on violators as well – Ashland faced $330,000 in penalties for the March 1994 LUST spill, although the company could reduce the fine if it complies with safety upgrades ahead of schedule.

Some fees, such as federal and state pipeline safety user fees, go toward regulation and inspection. Unlike liability-based excise taxes, such measures arguably help prevent problems rather than pay for pollution that has already occurred. Although user fees and fines on violators help fund the operation of oversight, taxpayers certainly bear some of the costs. Minnesota has over 50 thousand miles of pipelines.[58]

Fees typically do not come close to paying for petroleum-related damages. Legal remedies are a potential alternative to fees: private citizens have some recourse to the courts if they suffer injuries due to petroleum contamination. Yet causation is hard to establish.[59] And people often have no one to sue. Those injured by a LUST, for example, may find that the tank belonged to an independent dealer who bought from several distributors, then went bankrupt. Those who do win lawsuits often gain only injunctive relief – stopping further damages – rather than gaining compensation for damages that have already occurred.

Explicit fees and civil remedies place some responsibility for environment on the producers and consumers of oil. Despite these measures, the bulk of environmental damages from within-border spills and LUSTs probably rests implicitly on ordinary citizens.

One estimate of the costs associated with petroleum leaks and spills alone is 237 million barrel-equivalents of oil annually, or about $4.3 billion worth.[60] The Environmental Protection Agency estimates the cost just of cleaning up petroleum-contaminated groundwater at $790 million per year.[61] Delucchi estimates the health and environmental effects of leaking motor vehicle storage tanks at $120 million to $1.8 billion a year in current dollars.[62]

Oil spills in the ocean Oil is spilled into the ocean fairly often, but the amount spilled per incident tends to be relatively small – except in some widely known instances. (Because many tankers as yet have only a single hull, the probability of an oil spill in an accident is relatively high.[63]) One of the first large ocean oil spills was by the Amoco *Cadiz* in 1978, near the French coast. At the time, the losses were estimated at $190 to $290 million (in 1978 dollars).[64] More recently, 9,276 tanker accidents occurred worldwide in 1989, with 518 resulting in oil spills. One year later, one of the largest-ever spills took place – the Exxon *Valdez* dumped over 11 million gallons of oil off the shoreline of Alaska. The company paid a settlement of over $1 billion (and deducted most of it from taxable income). In 1991, only 3 known major oil spills occurred, putting about 55,000 gallons of oil in the ocean.

How much are U.S. residents affected by ocean oil spills? The *Valdez* incident may just be the tip of the iceberg — more than one-third of all petroleum products transported by oceangoing tankers pass through U.S. waters. [65] And the *Valdez* was exceptional: many spills probably go unreported and unattributed. As a result, most of the cost of ocean oil spills is likely borne by every-one but the responsible parties. Delucchi estimates the cost of oil spills as $2.4 to $6.0 billion a year in current dollars[66]

Mortality, morbidity, and reduced crop yields associated with petroleum pollution Whole hosts of medical ailments are related to exposure to petroleum products. Respiratory problems and cancer rank among the biggest offenders, although eye irritation, cardiovascular problems, and injuries caused by fires, explosions, and gasoline ingestion also occur.[67] Benzene, a major component of gasoline, is a proven human carcinogen. Other components of gasoline and oil likely cause cancer as well.[68] Reduced crop yields and acid rain are yet other side-effects of petroleum contamination.

Air pollution caused by fossil-fuel combustion and volatility is a major contributor to these ills – even with the standards set by the Clean Air Act (as amended) and the 1990 Pollution Prevention Act. Fuel combustion is responsible for almost half of the human-generated emissions of nitrous oxides, major ingredients of ozone and, in turn, smog.[69] It generates more than half of all carbon monoxide emissions and more than a third of all volatile organic-compound emissions.[70] It is a significant factor in a variety of air-quality and health-related problems, from ground-level smog and carbon monoxide to atmospheric acid rain. Even with new-car fuel-efficiency standards and pollution-emission requirements, motor vehicles generate an immense amount of pollution because we continue to drive more cars for longer distances each year.[71]

You might think that, compared to other states, Minnesota's air pollution problems are not so bad. You would be right, in a sense – state air generally falls within the National Ambient Air Quality Standards (NAAQS). Yet, because of petroleum products, the Twin Cities and Duluth frequently violate NAAQS. Among the largest single air polluters in Minnesota are Ashland and Koch. Ashland was penalized nearly $60,000 in April 1995 for violating air quality standards.[72] What is more, both the Environmental Protection Agency and Congress acknowledge that scientists often find that pollution concentrations they formerly thought were safe are in fact harmful.[73] Furthermore, the NAAQS do not reflect the latest scientific knowledge because the Environmental Protection Agency does not have the resource to keep the NAAQS up to date.[74] So Minnesota's air probably causes more harm than the statistics reveal.

Isolating the health and agricultural effects of exposure to petroleum products is a difficult task. Nevertheless, some studies have attempted it. The Office of Mobile Sources of the Environmental Protection Agency recently estimated that the U.S. cancer incidence associated with gasoline ranges from 400 to 754 cases per year; the incidence associated with diesel exhaust is 178 to 860 cases per year.[75] Private researchers have estimated even higher figures.[76] One study estimated that ozone air pollution is associated with 10 to 20 percent – and nearly 50 percent on bad days — of all respiratory hospital visits and admission. Another found that a 1 percent increase in the concentration of ozone was associated with a .015 percent increase in total mortality.[77]

Some researchers have couched their results in monetary rather than morbidity terms. Air pollutants such as ozone and nitrous oxide, substantially generated by motor vehicles, cause an estimated $2 billion to $4 billion loss in U.S. crop yields annually, for instance.[78] One study estimated that the costs of ozone alone generated by motor vehicles — in terms of health effects, lost labor hours, and reduced agricultural yields — came 8.3 cents per gallon of gasoline (in current dollars). That translates into more than $9 billion a year. [79] Others have calculated the cost of illness, premature death, reduced visibility, lower agricultural production, and damage to materials at $25 billion to $240 billion (current dollars) per year.[80]

Global warming Petroleum products cause health and other problems at current levels of consumption. Yet they also create significant problems for the future because they contribute to global warming. Experts estimate that up to one-half of greenhouse gas emissions (particularly carbon dioxide) are from fossil fuel combustion, with transportation activities being the largest single source.[81]

Why should we care? Because global warming could cost us considerably. Estimates of the current cost of US fuel-cycle emissions of greenhouse gas emissions range from $3 billion to $27 billion.[82] One scholar predicts that we may experience a 2.5 degree Centigrade warming by the year 2025 at current emission levels and trends. In the U.S. alone, that will translate into overall damages of $60 billion annually from agricultural losses, a rise in sea level, increased mortality, losses to the ski industry, increased electrical use from air conditioners, and lost water supply.[83]

Various researchers have estimated the benefits of curbing emissions so as to keep them at a certain level or to stabilize the atmospheric concentration of carbon dioxide.[84] The Office of Technology Assessment rated the economic health benefits of holding emissions constant at $633 million to $5 billion a year in current dollars.[85] These estimates focus on constant levels of emissions, however. If we want to halt global warming, we would actually need to cut emissions considerably. This would call for a substantial tax.[86] Experts have suggested that we need taxes ranging from 20 to75 cents per gallon of oil to accomplish this.

The current U.S. administration speaks of its commitment to addressing the problem of global warming. In his speech at the Rio de Janeiro conference held on Earth Day 1992, President Clinton expressed his desire to return U.S. emissions of greenhouse gases to 1990 levels by the year 2000.[87] Indeed, since 1990 the Environmental Protection Agency has issued or proposed numerous regulations and guidance designed to reduce air pollution and greenhouse gas emissions. But the agency does not have the resources to enforce its own standards and, in fact, has fallen far behind in implementing many of the provisions of the Clean Air Act.[88]

Conclusion From the various studies reviewed, we extracted a range of estimates for environmental and health costs of $25.5 billion to $267 billion. Our best-guess estimate is $30 billion, which translates to 11.5 cents per gallon. This figure gives little weight to the costs of global warming.

ENDNOTES

1 *The Environmental Costs of Transportation*, 1992, p. 44.

2 Just such a controversy arose not long ago between the Acropol Inn on Grand Avenue in St. Paul and its neighbor, Auto Clinic Inc., resulting in a lawsuit filed in Ramsey District Court.

3 Another such industry is pharmaceuticals, which reaps substantial benefits from the possessions tax credit.

4 Gas taxes and vehicle fees pay only a portion of the costs or road construction and maintenance. An in-depth study of local road financing in Minneapolis found that a significant portion of the costs of local roads comes from non-transportation taxes such as property taxes. The subsidy to motorists from the general taxpayer in Minneapolis is 18 cents per gallon. *Making the Car Pay Its Way: The Case of Minneapolis Roads*, John Bailey, Institute for Local Self-Reliance, 1992.

5 This analysis does not include the subsidies to energy consumption generated through low-income home energy assistance programs. For estimates of these, see Energy Information Administration, U.S. Department of Energy, *Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets*, November 1992.

6 We buy just over 17 million barrels of oil a day, 9 million of them imported. This translates into about 261 billion gallons of oil consumed each year. We consume about 116 billion gallons of gasoline each year. Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review*, April 1996. The share of oil devoted to gasoline use is actually rising: just over the past decade, it has gone from under 40 to over 45 percent of total petroleum used. Energy Information Administration, U.S. Department of Energy, *Monthly Energy Review*, various issues.

7 U.S. Bureau of the Census, *Current Population Reports*, series P25-1111, Series A State Population Projections; Statistics of Income Division, Internal Revenue Service, *SOI Bulletin*, Spring 1996.

8 American Automobile Manufacturers Association, *Motor Vehicle Facts & Figures*, 1994, p. 33. Adapted from data provided by the U.S. Department of Transportation, Federal Highway Administration. These figures do not include military vehicles.

9 Federal excise taxes are currently 18.3 cents per gallon of gasoline, of which 4.3 cents go into the general fund and the remainder into the highway trust fund. Minnesota excise taxes that are transferred to the state's Department of Transportation for the state highway trust fund equal 20 cents per gallon. In terms of total state and local taxes on gasoline (including excise and sales tax), Minnesota ranks just about in the middle of all states. See D.C. Department of Finance and Revenue, *Tax Rates and Tax Burdens in the District of Columbia: A Nationwide Comparison*, June 1995, and *Survey of State and Local Gasoline Taxes*, Minnesota House Research Information Brief, February 1994.

[10] Of course, most of us enjoy some tax preferences – the mortgage interest deduction, for example. Yet the benefits of these sorts of tax preferences are spread much more widely across people than the preferences concentrated in a given industry.

[11] Alternatively, less taxes for some might mean a greater budget deficit (and therefore higher taxes later) or fewer services provided.

[12] Jane Gravelle, *Economic Effects of Taxing Capital Income*, MIT Press, 1994, p. 54ff.

[13] Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 1988-1992*, February 1987. For three reasons, one must take care in interpreting tax expenditure estimates. Certain provisions overlap, so double-counting is a possibility. This is probably not a major issue for tax expenditures related to petroleum. Not only might tax expenditures overlap, they do not include behavioral effects. That is, the data do not account for shifts in output generated by alterations in the tax code. Again, this is likely a minor matter here because the elasticity of demand for petroleum is inelastic (quantity demanded is relatively unresponsive to price), at least in the short-run. Finally, tax expenditures are calculated on the basis of current cash flows, rather than in present-value terms. In most instances, the differences in calculation are minimal. For tax preferences that generate benefits for a number of periods, however, one must use a present-value calculation to determine an accurate revenue-loss figure attributable to a given fiscal year. For the most part, I can rely on cash-flow numbers; for certain provisions, however, I report present-value figures.

[14] The Treasury Department's noted 1984 blueprint for tax reform is just one of many documents that have called for repealing the tax incentives enjoyed by the petroleum industry. Office of the Secretary, U.S. Department of the Treasury, *Tax Reform for Fairness, Simplicity, and Economic Growth,* November 1984.

[15] *U.S. Dependence on Foreign Oil*, Senate Hearings 104-21, *Domestic Oil and Gas Tax Proposals to Increase Production*, Senate Hearings 103-971.

[16] Tax expenditure data come primarily from Office of Management and Budget, *Budget of the United States Government, Fiscal Year 1997, Analytical Perspectives*, pp. 61-87. Naturally, certain people benefit from the subsidies: some benefits may flow to stockholders and executives; arguably, some may go to employees and creditors as well. Yet the salient point about subsidies is that they encourage more investment and activity in a particular enterprise than is economically warranted: on net, they cost society. The data reported here represent the net cost to taxpayers.

[17] Internal Revenue Code sections 611 to 613A.

[18] Internal Revenue Code section 29. The provision applies only to domestic production from facilities or wells in place before 1993.

[19] Statistics of Income, Internal Revenue Service, *SOI Corporate Tax Return Source Books*, 1991 and 1992 returns.

[20] *New York Times*, May 14, 1995, p. 1.

[21] Internal Revenue Code section 263.

[22] These numbers pertain to the present value of the tax expenditure.

[23] See particularly *Louisiana Land and Expl. Co.*, 102 T.C. 21 (1994). Reported in *Tax Notes*, September 25, 1995, p. 1560.

[24] Internal Revenue Code section 43. Also see Code sections 193 and 263.

[25] Internal Revenue Code sections 901 and following.

[26] Not only can companies manipulate timing, they can take advantage of swings in exchange rates to minimize tax burdens. See Jenny Wahl, "Taxation of Foreign Exchange Gains and Losses and the Tax Reform Act of 1986," *National Tax Journal*, March 1989.

[27] Statistics of Income, Internal Revenue Service, *SOI Bulletin*, Winter 1995-1996, from pp. 99-104. These numbers are based on proportions of assets and of receipts.

[28] *SOI Bulletin*, Winter 1995-1996, from pp. 115-129. Foreign taxes paid, accrued, or deemed paid amounted to about $6.17 billion.

[29] See the protest from Texaco on p. 1327 of *Tax Notes*, Mar. 4, 1996. Treasury Department officials relayed much of the background information to me.

[30] In one recent suit, the IRS determined that Amoco had a $466.2 million deficiency for 1980-82. Amoco had claimed a foreign tax credit for taxes paid to Egypt; the IRS argued that the money had been funneled back through an Egyptian subsidiary as a government subsidy. The IRS lost. Reported in *Tax Notes*, April 10, 1995, pp. 452-54. In a suit from December 22, 1993, the Tax Court rejected the IRS's reallocation of income for Exxon. See *Tax Notes*, January 9, 1995.

[31] These numbers correspond to present value calculations.

[32] Statistics of Income, Internal Revenue Service, *Corporate Tax Return Source Books*, 1991 and 1992 returns.

[33] See testimony by Friends of the Earth, *Domestic Oil and Gas Proposals to Increase Production*, Senate Hearing 103-971, p. 171.

[34] Some have suggested that states also subsidize petroleum by imposing sales taxes on gasoline that are relatively lower than sales taxes on other items. Union of Concerned Scientists, *Money Down the Pipeline: Uncovering the Hidden Subsidies to the Oil Industry*, September 12, 1995. I could not find sufficient evidence to adopt this reasoning. See for example D.C. Department of Finance and Revenue, *Tax Rates and Tax Burdens,* and *Survey of State and Local Gasoline Taxes*, Minnesota House Research Information Brief.

[35] *Monthly Energy Review*, April 1996. Also see Congressional Office of Technology Assessment, *U.S. Oil Import Vulnerability*, 1991.

[36] Statement by Susan Tierney, Assistant Secretary for Policy, U.S. Department of Energy, *U.S. Dependence on Foreign Oil*, Senate Hearing 104-21; Energy Information Administration, Department of Energy, *Monthly Energy Review*, June 1996.

[37] States as well as the federal government attempt to protect valuable petroleum resources. States like Alaska and Texas require oil companies to pay royalties (in cash or in kind) and severance taxes, in part to slow down depletion. Yet calculating the value of extracted oil, particularly in Alaska where no on-site market exists, is often a matter of controversy. As a result, the amount of royalties and taxes paid may not fully compensate states for the loss of their resources.

[38] These figures estimate the cost to taxpayers of protecting petroleum. If oil companies instead shelled out protection money, they would probably be allowed to deduct at least part of their expenses from taxable income, just as any business might deduct insurance premiums or guards' salaries. If all such expenses were deductible and losses fully carried over, taxpayers would effectively bear 35 percent of these costs. (If expenses were high enough, companies would have to carry over losses to other years. Because carryover periods are limited, some losses might never be deducted. Taxpayers would then bear less than 35 percent of costs.) Existing costs of protecting petroleum reserves, relative to this "deductability baseline," therefore come to $17.3 billion to $46 billion per year. How plausible is this scenario? Oil companies would not be likely to hire guards to protect supplies, at least not to the extent that U.S. military forces currently do. Companies might, however, insure against some losses, either through third parties or on their own.

[39] Office of Management and Budget, *Budget.* The total Defense Department budget comes to over $263 billion in 1996. This figure does not account for emergency energy preparedness (about $150 million annually) nor international security assistance.

[40] Testimony by Joshua Gotbaum, Department of Defense, *U.S. Dependence on Foreign Oil*, Senate Hearing 104-21, p. 27. His Office has been abolished.

[41] See *Persian Gulf War Veterans and Related Issues*, hearing before subcommittee on oversight and investigations, Committee on Veterans Affairs, House of Representatives, June 9, 1993.

[42] This breaks down into $260 million for equipment and the remainder for active shore forces. *Cost of War in the Gulf*, hearing before the Committee on the Budget, House of Representatives, February 27, 1991.

[43] Congressional Research Service, *The External Costs of Oil Used in Transportation*, June 17, 1992.

[44] Earl Ravenal, *Designing Defense for A New World Order*, Cato Institute, 1992, p. 46, calculated the cost of maintaining a military presence in the Middle East at $50 billion. James MacKenzie, a researcher at World Resources Institute and frequent commentator on the social cost of petroleum, testified to the same number. *The Environmental Costs of Transportation Energy Use*, hearing before the subcommittee on the environment of the Committee of Science, Space, and Technology, House of Representatives, September 17, 1992. Edwin Rothschild, *Oil Imports, Taxpayer Subsidies, and the Petroleum Industry*, Citizen Action, May 1995, put the national security cost of oil at $57 billion annually. Also see General Accounting Office, *Southwest Asia: Cost of Protecting U.S. Interests,* August 1991. For a comprehensive analysis, see the 1994 report for the National Renewable Energy Laboratory, *Fuel Ethanol "Special Studies"* by Energetics, Inc. located at Website http://rredc.nrel.gov/biomass/doe/rbep/ethanol

[45] Joshua Gotbaum, Assistant Secretary for Economic Security, Department of Defense, estimated the incremental costs of the war at $57 billion. *U.S. Dependence on Foreign Oil*, Senate Hearing 104-21, p. 27. The Office of Management and Budget puts the cost closer to $100 billion or more. *Update on Costs of Desert Shield/Desert Storm*, hearing before the Committee on the Budget, House of Representatives, May 15, 1991.

[46] Testimony by Joshua Gotbaum, *U.S. Dependence on Foreign Oil*, Senate Hearing 104-21.

[47] Conversation with officials at the Strategic Petroleum Reserve Office, U.S. Department of Energy. Budget requests for maintenance for 1996 were $264 million. Office of Management and Budget, *Budget.* The original goal for the Reserve was 1 billion barrels, but we are currently depleting the Reserve rather than adding to it.

[48] The oil in the Reserve cost somewhere between $19 and $21 billion to purchase; its current market value (at just over $18 per barrel) is much less – about $10.5 billion. If the Reserve were sold and the proceeds invested at 7 percent, taxpayers would enjoy annual returns of about $724 million. At 10 percent, the amount would be $1,035 million annually.

[49] Office of Management and Budget, *Budget.*

50 Reported in the *Minneapolis Star-Tribune*, May 14, 1995.

51 Estimated by the Office of Underground Storage Tanks, Environmental Protection Agency. Also see *Underground Storage Tanks*, hearing before the subcommittee on energy and agriculture, Committee on Small Business, House of Representatives, November 18, 1987.

52 The *Washington Post* of May 10, 1992, had a story about thousands of leaky gas and oil tanks in the D.C. area, for example.

53 Conversation with environmental lawyers in San Francisco.

54 Reported in the *Minneapolis Star-Tribune*, August 31, 1995, and May 24, 1995.

55 Only Superfund retains some interest – Senate bill S. 2027 proposed a 5-year extension of Superfund; it has been referred to the Senate Finance Committee. One source at the Environmental Protection Agency estimated that the funds will pay for no more than 18-months'-worth of cleanup. They may not last that long: some Congressmen have suggested tapping the trust funds to pay for the general costs of government operations.

56 Siamack Shojal, ed., *The New Global Oil Market: Understanding Energy Issues in the World Economy*, Praeger, 1995, p. 177

57 The petroleum industry also enjoys exclusions or other special provisions in the Clean Water Act, the Clean Air Act, the Safe Drinking Water Act, the Hazardous Liquid Pipeline Safety Act, the Oil Pollution Act, and the Emergency Planning and Community Right-To-Know Act. Testimony by Friends of the Earth, *Domestic Oil and Gas Proposals to Increase Production*.

58 Because of certain provisions our state probably is more successful at maintaining safety than others are. Minnesota's Office of Pipeline Safety is located in the Office of Public Safety and can quickly call upon other agencies in emergencies; in contrast, most such offices are located in Offices of Public Utilities. Also, Minnesota's Office is responsible for both instate and interstate pipelines; most states regulate only instate pipelines and must rely on federal officials to inspect interstate lines. About one-third of the state Office's budget is covered by a federal grant. Conversations with officials in Minnesota's Office of Pipeline Safety.

59 For one account of the difficulties of establishing causation, see Jonathan Harr, *A Civil Action*, Random House, 1995.

60 Testimony by Friends of the Earth, *Domestic Oil and Gas Proposals to Increase Production*, Senate Hearing 103-971.

61 ABB Environmental Services, *The OPA Liner Study*, January 24, 1993, p. 57.

62 Mark DeLucchi, *Summary of Non-monetary Externalities of Motor Vehicle Use*, Draft prepared for the Union of Concerned Scientists, October 1995.

63 Legislation passed after the Exxon *Valdez* spill requires double hulls for new oceangoing tankers unless the Coast Guard finds a good alternative. Single hulls will be phased out in U.S. waters by 2015. Ships flying foreign flags are more prone to spill off our coasts. Eric Anderson and Wayne Tilley, "Oil Spills," *Land Economics*, May 1995,

64 See National Oceanic and Atmospheric Administration, U.S. Department of Commerce, *Assessing the Social Costs of Oil Spills: The Amoco Cadiz Case Study*, 1983.

65 Anderson and Tilley, "Oil Spills," p. 216.

66 DeLucchi, *Summary*

67 Between 1983 and 1992, fires and explosions in U.S. oil refineries and petrochemical plants killed more than 80 workers, injured 900 workers, and caused the evacuation of thousands. Testimony by Friends of the Earth, *Domestic Oil and Gas Proposals to Increase Production*. Approximately 30,000 cases of accidental ingestion of gasoline occurred in 1987, according to the American Association of Poison Control Centers, with almost 30 percent being children aged 2 years or younger.

68 A variety of cancer studies exist. See for example Myron Mehlman and Arthur Upton, eds, *The Identification and Control of Environmental and Occupational Diseases: Hazards and Risks of Chemicals in the Oil Refining Industry*, Princeton Scientific Publishing Co., Inc., 1994; Office of Health and Environmental Assessment, Environmental Protection Agency, *Evaluation of the Carcinogenicity of Unleaded Gasoline*, April 1987; Office of Research and Development, Environmental Protection Agency, *Air Quality Criteria for Ozone and Related Photochemical Oxidants*. Also see Environmental Criteria and Assessment Office, Environmental Protection Agency, *Health Assessment Document for Diesel Emissions*, 1990;.

69 Office of Research and Development, Environmental Protection Agency, *Air Quality Criteria for Ozone and Related Photochemical Oxidants*, vol. 1, p. 3-63; Mackenzie et al., *The Going Rate*; David Greene and Danilo J. Santini, *Transportation and Global Climate Change*, 1993; Office of Research and Development, Environmental Protection Agency, *Air Quality Criteria for Carbon Monoxide*, December 1991, p. 6-9; and Office of Research and Development, Environmental Protection Agency, *Air Quality Criteria for Ozone*

and Related Photochemical Oxidants, vol. 1, p. 3-63. See as well the testimony of Victor Rezendes, Director, Energy and Science Issues, Government Accounting Office, *The Environmental Costs of Transportation*, 1992, and testimony of Robert Sussman, Environmental Protection Agency, *Global Climate Change and Air Pollutants*, hearings before the subcommittee on health and environment, Committee on Energy and Commerce, House of Representatives, August 4 and October 26, 1993.

70 Mackenzie et al., *The Going Rate*.

71 See MacKenzie et al., *The Going Rate*, and testimony of James MacKenzie, *The Environmental Costs of Transportation Energy Use*, 1992.

72 Reported in the *Minneapolis Star-Tribune*, August 31, 1995, February 4, 1995..

73 See the legislative history to the Clean Air Act Amendments of 1977, and *Lead Industries Ass'n v. Environmental Protection Agency*, 647 F.2d 1130 (CD Cir. 1980), *cert. den.*, 449 U.S. 1042 (Dec. 8, 1980)

74 See *In the Matter of the Quantification of Environmental Costs Pursuant to Law of Minnesota 1993, Chapter 356, Section 3*, State of Minnesota Office of Administrative Hearings, Findings of Fact, Conclusions, Recommendation, and Memorandum, 6-2500-8632-2, E-999/CI-93-583, p. 24.

75 Adapted from J.M. Adler and P.M. Carey, "Air Toxics Emissions and Health Risks from Mobile Sources," presented at the annual meeting of the Air and Waste Management Association, 1989.

76 Myron Mehlman, "Carcinogenicity of Motor Fuels: Gasoline," in Mehlman and Upton, eds., *The Identification and Control of Environmental and Occupational Diseases.*

77 P.L. Kinney and H. Ozkaynak, "Associations of Daily Mortality and Air Pollution in Los Angeles County," *Environmental Resources* 54, 1991, 99-120.

78 Office of Research and Development, Environmental Protection Agency. For estimates of certain effects on agriculture, see the summary in Office of Research and Development, Environmental Protection Agency, *Air Quality Criteria for Ozone and Related Photochemical Oxidants*, July 1996, vol. II, table 5-38.

79 Mark French, *Efficiency and Equity of a Gasoline Tax Increase*, Paper #33, Finance and Economics Discussion Series, Federal Reserve Board of Governors, July 1988.

80 UC-Davis researchers, reported in MacKenzie et al., *The Going Rate*. Mark Delucchi, as reported by the Union of Concerned Scientists, *Money Down the Pipeline*, estimated damages of gasoline to human health alone to be $42.1 to $181.7 billion a year in 1990 dollars.

81 Mackenzie et al., *The Going Rate*, estimated that driving leads to 25 percent of carbon dioxide emissions. Others have estimated even higher figures. See for example the testimony of Howard Geller and John DeCicco, *The Environmental Costs of Transportation Energy Use*, 1992, and the testimony of Robert Sussman, *Global Climate Change and Air Pollutants*, 1993. These experts estimate that transportation accounts for one-third of greenhouse gases.

82 Union of Concerned Scientists, *Money Down the Pipeline*, Table 7 (converted to 1996 dollars).

83 William Cline, *Economics of Global Warming*, Institute for International Economics, 1992. Also see Organization for Economic Cooperation and Development, *Transport Policy and Global* Warming, 1993, Global *Warming*, 1992, and *Climate Change: Evaluating the Socio-Economic Impacts*, 1991.

84 The Intergovernmental Panel on Climate Change, *Climate Change, the IPCC Scientific Assessment*, Cambridge, 1990, recommended that global carbon dioxide emissions should be reduced by 60 to 80 percent in order to stabilize concentrations.

85 Congressional Office of Technology Assessment, *Catching Our Breath: Next Steps for Reducing Urban Ozone*, July 1989.

86 Congressional Budget Office, *Energy Use and Emissions of Carbon Dioxide: Federal Spending and Credit Programs and Tax Policies*, December 1990; Cline, *Economics of Global Warming*; Dale Jorgenson and Peter Wilcoxen, *Reducing U.S. Carbon Dioxide Emissions: The Cost of Different Goals*, CSIA Discussion Paper 91-9, Kennedy School, Harvard University (cited in MacKenzie et al., *The Going Rate*).

87 Representative Henry Waxman has noted that the plans proposed to do this are largely a collection of voluntary measures without any real enforcement mechanisms. *Global Climate Change and Air Pollutants*, 1992, p. 97. Waxman was the chair of the subcommittee.

88 *Global Climate Change*, 1993, p. 42.

Senators Lourey, Murphy and Moua introduced--

S.F. No. 181: Referred to the Committee on Transportation.

A bill for an act

relating to Carlton County; dedicating Biauswah Bridge over the St. Louis River and Roussain Cemetery in Jay Cooke State Park in Carlton County; amending Minnesota Statutes 2004, section 161.14, by adding a subdivision.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA:

Section 1. Minnesota Statutes 2004, section 161.14, is amended by adding a subdivision to read:

Subd. 51. [BIAUSWAH BRIDGE.] The bridge over the St. Louis River that is part of Legislative Route No. 185, marked as Trunk Highway 23 on the effective date of this section, is named and designated "Biauswah Bridge." After consulting with the Fond du Lac Band of Lake Superior Chippewa, the commissioner of transportation shall adopt a suitable marking design to memorialize this bridge and shall erect the appropriate signs, subject to section 161.139.

Sec. 2. [ROUSSAIN CEMETERY; CARLTON COUNTY.]

On agreement of the Fond du Lac Band of Lake Superior Chippewa and the city of Duluth, the commissioner of natural resources shall name and dedicate the cemetery in Jay Cooke State Park on land leased to the band by the city of Duluth as "Roussain Cemetery." After consulting with the Fond du Lac Band and the city of Duluth, the commissioner shall adopt a suitable marking design to memorialize the cemetery and erect the appropriate signs or memorials on assurance of the availability

<u>of funds from nonstate sources sufficient to pay all costs related to designing, erecting, and preserving the signs or memorials.</u>

Senator Chaudhary introduced--

S.F. No. 260: Referred to the Committee on Environment and Natural Resources.

A bill for an act

relating to natural resources; requiring youths under age 13 to wear personal flotation devices on watercraft; amending Minnesota Statutes 2004, sections 86B.311, by adding a subdivision; 86B.501, by adding a subdivision.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA:

Section 1. Minnesota Statutes 2004, section 86B.311, is amended by adding a subdivision to read:

Subd. 6. [PERSONAL FLOTATION DEVICE REQUIRED UNDER AGE 13.] A person may not operate a watercraft upon the waters of this state with a person under age 13 on board, unless the person under age 13 is wearing a United States Coast Guard-approved Type I, II, III, or V personal flotation device.

Sec. 2. Minnesota Statutes 2004, section 86B.501, is amended by adding a subdivision to read:

Subd. 3. [PERSONAL FLOTATION DEVICE REQUIRED UNDER AGE 13.] A person under age 13 must wear a United States Coast Guard-approved Type I, II, III, or V personal flotation device when on board a watercraft upon the waters of this state.