Nebraska Biomass Study

Nebraska Agricultural
Resource Base Assessment

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For the
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In cooperation with the
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Forward

The Agricultural Resource Assessment is a joint project of the Nebraska Energy Office and the Nebraska Gasohol Commission. Funds for this study were provided by the NEO, using federal funds under Public Law 94-163.

The primary intent of this study was to determine the total amount of agricultural products grown in this state and the potential amount available for use as liquid fuels.

The impetus for the study is the potential economic disruption to the state of Nebraska as a result of a cutoff of imported petroleum.

The first question asked was: "What is a viable liquid fuel option for the state, if and when such a shortfall occurs?" The answer is ethanol.

The next question was: "Do we produce enough agricultural products from which ethanol can be made?" The answer is, we do.

This study is not designed to determine whether or not the crops should be converted to ethanol production, or what the economic consequences would be. It is strictly a resource assessment.

The objective of this study was to compile detailed information from existing sources relating to Nebraska's agricultural and energy resources. This information will be used in making decisions related to Nebraska's ethanol production potential, in determining future research projects which can expedite an implemented ethanol industry in Nebraska, and in providing specific information for entities which are attempting to identify optimum locations for ethanol production facilities. This feasibility study will attempt to investigate primarily the indigenous fuel resource base in Nebraska and then relate these resources to the total U.S. supply. The first resources to be considered are the traditional fossil fuels, among which coal, petroleum, and natural gas will be discussed. Following this discussion will be an analysis of the biomass resource base, which has the potential to be used in alcohol production.

Coal

The first fossil fuel to be considered is coal. With a variety of uses, coal is included in this study for its traditional, present, and potential fuel applications. Traditionally, coal was a heating source, then later was largely replaced by oil, natural gas, and hydroelectric power. Because of shortages of natural gas and oil in the past, today, coal is a fuel attracting renewed interest.

This renewed interest is demonstrated by an increase in production and consumption of coal, and a decrease in the use of other fuels. Contributing to the highest production of coal in 30 years, 26 states were responsible for the large quantities of coal produced in the U.S. The total U.S. 1980 production of 835.4 million short tons was 54.3 million short tons more than the 1979 production (781.1 million short tons) and 275 million short tons more than the 1950 production (560.4 million short tons). Domestic coal consumption has also increased with increased production. The total 1980 consumption of 705.9 million short tons increased from the 1979 consumption of 680.5 million short tons. The increased consumption and production is summarized by this chart, (Table 1).

Table 1
US. Domestic Coal Production and Consumption

	COAL PRODUCTION	COAL CONSUMPTION
1979	781.1 million sh. tons	680.5 million sh. tons
1980	835.4 million sh. tons	705.9 million sh. tons.

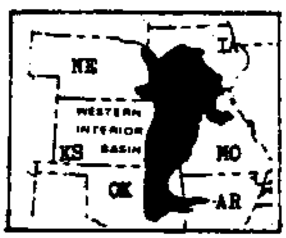
Source: EIA 1980 Annual Report to Congress, p. 125.

Coal is used as a primary fuel in the generation of electricity. In fact, U.S. electric utilities, previously using oil or natural gas as primary fuels, presently are the leading consumers of coal. Electric plants, which are fired by coal number 368, whereas oil-fueled plants total 327 and gas-fueled plants 328.

Electric utility plants in Nebraska are no exception to the national trend of increased coal usage. The 5 major Nebraska electric utilities (Nebraska Public Power District, Omaha Public Power District, Lincoln Electric System, Grand Island, and Fremont), which provided 88.7% of all the state's electricity in 1980, depended upon coal as the primary fuel source. There are 5 coal-fired plants, 2 oil-fueled plants and 6 plants supplied with natural gas in Nebraska. With the development of 2 new coal-fired electric generation plants, one in Nebraska City and the other located at Sutherland, the use of coal increased even more, while consumption of other fuels decreased in the industrial, agricultural, and residential sectors. Additional demand for coal in 1981 will be created as new coal-fired power plants begin operation at Hastings and Grand Island.

Historically speaking, the existence of Nebraska coal was known, and coal was mined as early as 1850. Large scale commercial mining began in 1906, but soon declined and ceased later in the century; by 1976 Nebraska coal mines had closed. The following map (Figure 1) shows that eastern Nebraska is located in a larger region known as the Western Interior Basin.

Figure 1
Coal Fields in the Western Interior Basin

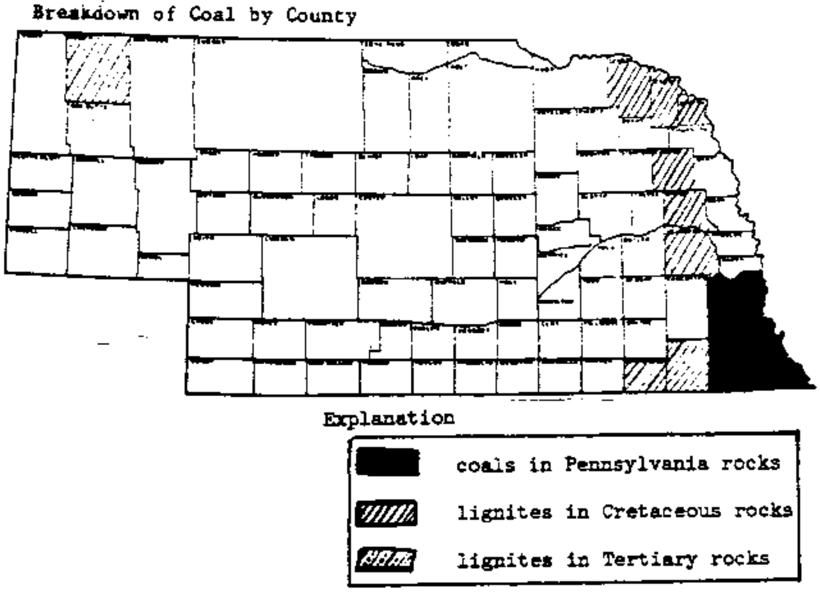


Source: Burchett, Coal Resources of Nebraska, p. 67.

This basin stretches into parts of Iowa, Kansas, Missouri, Oklahoma, and Arkansas.

The coal in this basin is predominately medium- and high-volatile bituminous coal, a coal of the Pennsylvania system; however, other coals in other systems are also found in Nebraska. Three systems of coal are found here--Pennsylvania, Cretaceous, and Tertiary--among which are various rankings of coal from lowest to highest: lignite, subbituminous, and bituminous. The highest ranked coal, anthracite, is not found in Nebraska. The following map shows specific areas of the various coals in Nebraska (Figure 2).

Figure 2
Breakdown of Coal by County



Source: Burchett, Coal Resources of Nebraska, p. 25.

Some of Nebraska's ranked coal, which is labeled as medium- and high-volatile bituminous coal, remains much too thin for underground mining, but this coal can be strip mined. The reserves of strippable, yet uneconomically extractable coal are estimated at 10.2 million tons. This coal, once considered expensive and nearly impossible to mine, may possibly be obtained with the development of new mining equipment. This coal supply, which does not necessarily need to be extracted, has the potential to be transformed into pipeline gas in place, although in situ gasification poses an environmental concern due to its impact on local ground water quality. Since the present, although limited, reserves of oil and gas are increasingly expensive compared with the price of coal, coal's importance as a source of pipeline gas, methane, could increase. And even though the lignite and bituminous coal found in Nebraska may be inferior in quality as well as mass quantities of coals found in other coal bearing areas, their potential as fuel resources should be actively considered and explored.

With renewed interest in coal, Nebraska gains new importance as a possessor and potential producer of this fuel. However, Nebraska's coal production may be minimal due to the size of the coal bearing area—1.3% of the state's total area of 77,227 square miles. If compared to other coal bearing areas which are relatively equal in size (for example, 45% of North Dakota's 70,665 square miles is coal bearing), Nebraska's potential appears insignificant. On the other hand, this small contribution of coal can contribute significantly to other energy resources which can add up to larger energy sum totals.

Oil and Natural Gas

On a national scale, the 1980 U.S. crude oil production from 542,000 operating oil wells averaged about 16 barrels per day per well, or a total domestic average of 8.6 million barrels per day. In fact, oil production during 1980 rose .5% over the production of 1979; however, even with this increase in domestic production, domestic oil supplies are not sufficient enough to satisfy U.S. consumption of 17.0 million barrels per day. These 1980 supplies were supplemented by 6.8 million imported barrels per day; imports equal nearly 40% of the U.S. consumption. The following chart (Table 2) illustrates not only the decadal U.S. production, but consumption and import rates of petroleum as well.

Table 2
Decadal U.S. Production, Imports, and Consumption.

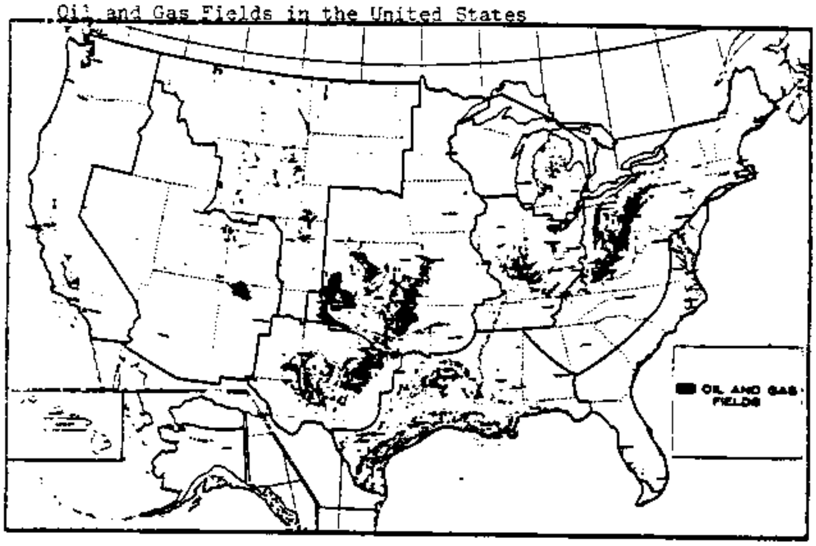
Year	Domestic Production Crude Oil	Price	Imports Crude Oil	Price	Consumption Products
1970	9.18	$3.46	3.42	$2.96	14.70
1971	9.03	$3.68	3.93	$3.17	15.21
1972	9.00	$3.67	4.74	$3.22	16.37
1973	8.78	$4.17	6.26	$4.08	17.31
1974	8.38	$7.18	6.11	$12.52	16.65
1975	8.01	$8.39	6.06	$13.93	16.32
1976	7.78	$8.84	7.31	$13.48	17.46
1977	7.87	$9.55	8.81	$14.53	18.43
1978	8.35	$10.61	8.36	$14.57	18.85
1979	8.18	$14.27	8.46	$21.67	18.51
1980	8.60	$24.23	6.79	$33.89	17.03

Source: EIA 1980 Annual Report to Congress, Vol.2, pp.45,49,91.

This chart indicates that during the decade (1970-1980) domestic production varied slightly. (The 1980 production increased marginally over the 1979 production.) On the whole, imports of crude oil and refined products moderately increased until 1978, when a noticeable decline began. The price per barrel of domestic and imported petroleum has sharply increased over the years, especially from 1973 to 1974 and from 1979 to 1980. Consumption of these products has remained consistent in the last decade. In view of the 1980 consumption specifically, petroleum products returned to a lower level than in 1975. In short, with a slight increase in production and with a decrease in imports and consumption, the U.S. experienced the highest prices ever for petroleum in 1980.

Domestic supplies of petroleum (the second traditional fossil fuel) and natural gas (the third traditional fossil fuel) are located throughout the continental U.S. and Alaska. Most continental oil and gas fields are situated in the central southern and eastern states. The following map displays the known oil and gas fields in the U.S.

Figure 3
Oil and Gas Fields in the United States



Source: U.S. Geological Survey Circular 725, p. 19

If one focuses upon centrally located Nebraska, Figure 3 suggests that the major oil and gas fields are located in other states. This would indicate that Nebraska would be dependent upon other regions for imported oil and gas. In the event of a shortage or disruption of imported fuels, Nebraska would suffer greatly because the very few oil and gas fields in Nebraska could not produce enough fuel to supply industry, agriculture, and the general public. The central U.S. location of Nebraska emphasizes the distance involved in importing fuels from other states. Figure 3 also suggests that the oil and gas fields in Nebraska are limited to the Panhandle, when in fact, oil and gas fields are predominately found in the central and southwestern portions of the state (Figure 4 and Figure 5).

Stimulated by rising petroleum and natural gas prices, drilling activity for oil and gas has increased over the past decade. On the whole, the U.S. discoveries were encouraging; the percentage of successful wells has also increased with drilling (Table 3).

Table 3
U.S. Wells Drilled for Oil and Gas

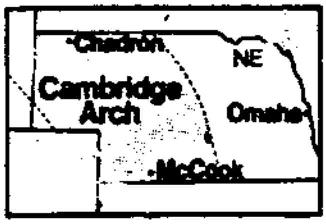
	WELLS DRILLED (000s)				PERCENT
YEAR	OIL	GAS	DRY HOLES	TOTAL	SUCCESSFUL WELLS
1970	13.02	3.84	11.26	28.12	60.0
1971	11.86	3.83	10.16	25.85	60.7
1972	11.31	4.93	11.06	27.29	59.5
1973	9.90	6.38	10.30	26.59	61.2
1974	12.78	7.24	11.67	31.70	63.2
1975	16.41	7.58	13.25	37.24	64.4
1976	17.06	9.08	13.62	39.76	65.7
1977	18.91	11.38	14.69	44.98	67.3
1978	17.78	13.06	16.22	47.06	65.5
1979	19.38	14.68	15.75	49.82	68.4
1980	26.98	15.74	18.09	60.18	70.3

Source: EIA 1980 Annual Report to Congress, Vol.2, p. 37.

Drilling activity is also increasing in Nebraska. More than 600 drilling permits were filed in 1980; additionally, 176 permits for oil and gas drilling were filed in the beginning three months of 1981. This increase in drilling may be attributed to decontrol. A possible target for this drilling resides in the Niobrara formation, which is isolated in the western two thirds of the state.

Within this Niobrara formation, the area which is considered the best potential producer of natural gas is the Cambridge Arch, which ranges from Chadron to McCook (Figure 4).

Figure 4
Natural Gas Potential in the Cambridge Arch



Source: Omaha World Hearld, May 24, 1981.

The Cambridge Arch is estimated to have a potential production capacity of a billion cubic feet per 160 acres. According to Paul Roberts, Director of the Nebraska Oil and Gas Conservation Commission, wells which were eventually capped because there existed no market pipeline were discovered here in 1978-1979. In fact, the potential production of natural gas from this area is contingent upon a pipeline which will be, in all probability, a reality. In 1980, the production of Nebraska's natural gas from wells totaled 2.6 billion cubic feet per year. Unfortunately, the total 1980 production of natural gas does not even equal 1% of the total 1980 consumption (which has decreased from 1979's consumption of 160 billion cubic feet) of 155 billion cubic feet in Nebraska.

On a national scale, total U.S. consumption and production are closely related. In 1980, the U.S. produced a marketable 20.09 trillion cubic feet and consumed 20.02 trillion cubic feet. If compared with the consumption (20.24 trillion cubic feet) and production (20.47 trillion cubic feet) rates of 1979, a slight decrease in production and consumption can be observed; but, on the other hand, prices per cubic foot most certainly have risen with inflation. The following chart (Table 4) compares the national consumption and production to the state's production and consumption of natural gas.

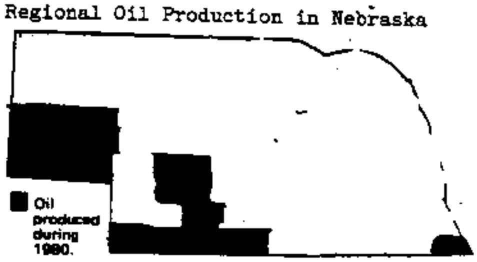
Table 4
Natural Gas Production and Consumption in the U.S. and in Nebraska

	YEAR	PRODUCED	CONSUMED
U.S. Natural Gas	1979	20.47 tril.cu.ft.	20.24 tril.cu.ft.
	1980	20.09 tril.cu.ft.	20.02 tril.cu.ft.
Nebraska Natural Gas	1979	2.6 bil.cu.ft.	160 bil.cu.ft.
	1980	2.5 bil.cu.ft.	155 bil.cu.ft.

Source: EIA 1980 Annual Report to Congress, Vol.2, pp.105,107, and NE Geological Survey, Nebraska Mineral Operations Review, 1980, p.2.

In addition to the natural gas supplies, oil is also found in Nebraska, but its location is not limited to the Cambridge Arch. A southeastern corner as well as a southwestern corner of Nebraska possess oil. The following map specifically illustrates the areas which produce oil (Figure 5).

Figure 5
Regional Oil Production in Nebraska



Source: "Business in Nebraska," UNL News, Vol. 61, No. 2, August 1981, p.3.

Over the years, Nebraska has produced less oil for a greater price. The following chart clearly illustrates a decrease in production from the years 1962 (24.885 million barrels) to 1978 (5.862 million barrels); production began to increase again, but only minimally in 1979 (6.068 million barrels). If the 1980 production total (6.240 million barrels is compared with the production of 1962 (24.885 million barrels), a sizable decrease in production can be noted. The 1980 production is a relatively small increase from the record low production of 1978.

Table 5
Nebraska Oil Production 1962-1980

Year	Oil Production*	Producing Wells	Barrels/ Well	Estimated Price/Barrel
1962	24.885	1,763	14,115	$2.83
1963	21.846	1,732	12,613	$2.70
1964	19.114	1,711	11,171	$2.70
1965	17.216	1,611	10,687	$2.66
1966	13.850	1,511	9,166	$2.72
1967	13.373	1,430	9,352	$2.75
1968	13.183	1,403	9,396	$2.79
1969	12.106	1,305	9,277	$2.98
1970	11.451	1,244	9,206	$3.09
1971	10.062	1,191	8,448	$3.38
1972	8.705	1,114	7,814	$3.38
1973	7.240	1,107	6,540	$3.87
1974	6.611	1,127	5,866	$6.83
1975	6.120	1,190	5,143	$9.01
1976	6.182	1,291	4,789	$8.99
1977	5,968	1,382	4,318	$10.46
1978	5.862	1,469	3,990	$11.40
1979	6.068	1,551	3,912	$16.81
1980	6.240	1,693	3,686	------

* millions of barrels

Source: "Business in Nebraska," UNL News, Vol. 61, No. 2, August 1981, p.1.

From this table (Table 5), it is evident that the 1980 oil production (6.240 million barrels) increased marginally--2.8% from the preceding year (6.068 million barrels). Since the number of producing wells in 1980 almost equal the number of producing wells in 1962 (1,693 wells in 1980 and 1,763 wells in 1962), this indicates that Nebraska wells have become less productive with time.

In Nebraska, 15 counties are involved in oil production. From the 1,693 wells which are actively operating an average of 3,686 barrels per well is produced per year. The following chart (Table 6) details each county's production.

Table 6
Nebraska's Oil Production by County

County	Oil Production (barrels)	Producing Wells	Barrels/ Well
Banner	577,522	194	2,977
Cheyenne	1,248,151	284	4,395
Deuel	108	0	108
Dundy	166,754	33	5,053
Frontier	99,364	15	6,624
Furnas	2,057	1	2,057
Garden	6,217	2	3,109
Harlan	25,787	10	2,579
Hitchcock	897,679	264	3,400
Kimball	1,215,874	337	3,608
Lincoln	877	1	877
Morrill	251,849	62	4,062
Red Willow	1,555,410	424	3,668
Richardson	45,286	30	1,510
Scotts	146,717	36	4,073

Source: "Business in Nebraska," UNL News, Vol. 61, No. 2, August 1981, p.2

Unfortunately, Nebraska is not prepared to refine all the oil currently produced in the state. Nebraska's only refinery, located at Scottsbluff, has an approximate production capacity of 5,600 barrels per day, but actually refines much less per day. Thus, the petroleum refining capacity is limited to a potential 2.04 million barrels per year. The potential refining capacity of 2.04 million barrels is 3 times less than the 1980 annual oil production of 6.240

million barrels; the overflow would need to be exported for refining. (Transportation and out-of-state refining costs would also add to the cost of the oil.) Thus, since all the oil which is produced instate cannot be refined instate, it is not immediately used instate. Nebraska must, then, rely on imports.

Since Nebraska is a major agricultural state and relies heavily upon petroleum, which makes farming possible, its dependence upon imported petroleum products is crucial. According to the Nebraska Petroleum Marketers, Inc., roughly 980 million gallons of petroleum (gasoline) and 400 million gallons of distillates (diesel, #2 heating oil, distillates) were imported into the state in 1980. These figures are sketchy estimations because accurate totals are not available. But, according to the Nebraska Energy Office, motor gasoline totaled approximately 792.8 million gallons, propane equaled 160.0 million gallons, and middle distillates were 478.4 million gallons. The following chart (Table 7) compares a two year span of fuels delivered in Nebraska.

Table 7
Total Fuel Delivered in Nebraska During 1979 and 1980

Fuel Type	Year 1979 (gallons)	1980 (gallons)
Motor Gasoline	202,749,123	160,020,000
Propane	798,942,326	792,825,000
Middle Distillates*	516,593,303	478,352,000

* Middle distillates include kerosene, home heating oil, diesel, and other middle distillates.

Source: Nebraska Energy Office.

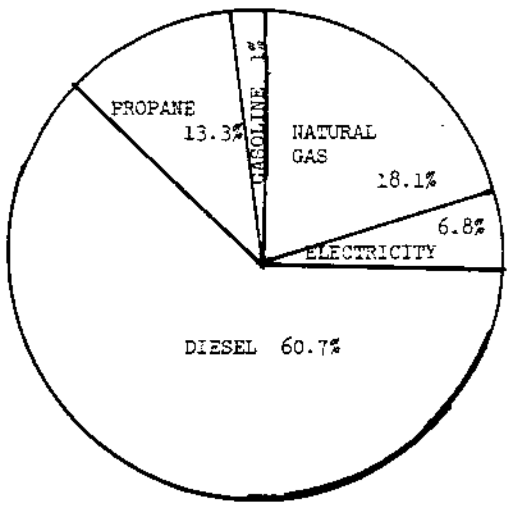
Table 7 indicates that the supply of each fuel type delivered into Nebraska in 1980 declined from the 1979 totals. If all the fuel types are added together, the sum total would equal approximately 1,431.2 million gallons of petroleum products delivered in the state. Since this total exceeds the total 1980 oil production (6.24 million barrels) of 262.08 million gallons or the total refining capacity figure (2.04 million barrels) of 85.68 million gallons,[1] it would indicate that Nebraska imports more petroleum products than it produces or refines. The total also implies that Nebraska uses more petroleum than it produces.

Although Nebraska's oil production over the years (1962-1980) has drastically decreased, the estimated value per barrel has dramatically increased. If annual Nebraska oil prices are compared, the 1962 total value was $70.4 million, whereas in 1979 60,068 million barrels of oil were valued at $102.0 million. (Refer to Table 5 for Nebraska prices per barrel and Table 2 for U.S. and foreign import oil prices. The price of oil not only in Nebraska, but also throughout the world has increased. Higher priced oil indicates an increased demand and perhaps foreshadows a scarcity of this nonrenewable resource. Higher priced oil affects all segments of society, particularly the agricultural sector.

In Nebraska one half (1/2) of all energy consumed in agriculture is used in irrigation. The other half is used in crop drying, field work, and market transportation. In irrigation, the needed power (3.32 million Btus/acre) is supplied by the fuels in Figure 6 for the 5.5 million acres of irrigated land in Nebraska. This irrigated land comprises approximately 1/4 of the total cropland, 22.4 million acres in Nebraska. The following chart (Figure 6) illustrates the distribution and percentage of energy usage in irrigation. The principle fuel used in irrigation is diesel. In fact, all the energy used in irrigation is from a fossil fuel resource; that is, electricity is generated usually by coal and natural gas.

In the event of a shortage of petroleum products, Nebraska's agricultural sector would suffer without diesel fuel, which is needed in irrigation, crop drying, field production and transportation to markets. Even though the diesel

Figure 6
Fuel Usage for Irrigation



Source: Nebraska Energy Office,
" Study of Nebraska Use of Liquid Fuels,"
p. 18.

fuel shortage during the Spring of 1979 did not reoccur in Nebraska during 1980, large supplies of imported oil (40%), lessened domestic petroleum production, and rising crude oil prices as well as other inflated energy prices should be scrupulously considered as factors for potential shortages; replacements, alternatives, or supplements to petroleum products could alleviate the pressures of a potential shortage and could remedy the nation's and Nebraska's extreme dependence upon imported petroleum products.

A Summary of Fuel Bases

To summarize the energy situation, production and consumption rates of fossil fuels in the U.S. and Nebraska should be assessed (Table 8).

Table 8
Summary of U.S. Nebraska Production and Consumption Rates

U.S. FUEL	1979 PRODUCTION	1979 CONSUMPTION
Coal	781.1 million short tons	680.5 million short tons
Natural Gas	20.47 trillion cubic feet	20.24 trillion cubic feet
Petroleum	8.18 million barrels/day	18.51 million barrels/day
	1980 PRODUCTION	1980 CONSUMPTION
Coal	835.4 million short tons	705.9 million short tons
Natural Gas	20.09 trillion cubic feet	20.02 trillion cubic feet
Petroleum	8.6 million barrels/day	17.0 million barrels/day
NE FUEL	1979 PRODUCTION	1979 CONSUMPTION
Coal	none	2.5 million short tons
Natural Gas	8.6 billion cubic feet	160 billion cubic feet
Petroleum	6.06 million barrels	1,399.2 million gallons *1
	1980 PRODUCTION	1980 CONSUMPTION
Coal	none	3.2 million short tons
Natural Gas	2.5 billion cubic feet	155 billion cubic feet
Petroleum	6.24 million barrels	1,269.5 million gallons *

* estimations

*1 No aviation fuel

Sources: EIA/1980 Annual Report to Congress, pp. 45,49,105,107; NEO/ "Nebraska Monthly Petroleum Status Report," July 31,1981, pp. 5,7,9,11,17.

This chart shows that consumption of natural gas as well as petroleum decreased in 1980, whereas the use of coal increased. This coal was primarily consumed by industry and electric utilities, not by the residential sector. Industries are using more coal to replace increasingly more expensive natural gas. A decrease in the 1980 consumption and production of natural gas and petroleum may be attributed to conservation efforts and to higher prices. The increased domestic coal consumption and production was apparently not affected by increased domestic coal prices.

In 1978, Nebraska ranked as the forty-second state in an energy position which measures the difference between primary energy production and primary energy consumption.[2] In fact, the energy produced in Nebraska (1980) from oil and gas was less than 7% of all energy consumed in the state. Accordingly, it is estimated that Nebraska currently imports 95% of its energy (coal, gas, and oil) because fossil fuels are limited within the state. This large amount of imported fuel illustrates Nebraska's major dependence upon the nation's fuel supply; therefore, the national supply will directly affect the state's supply.

Currently, the fuel supply outlook is that the U.S. appears well-stocked with coal, that hydroenergy and natural gas supplies are adequate, but domestic supplies of petroleum products will fall far short of domestic demand; however, the nonrenewable fuel supply may be misleading. If one considers the proved world and U.S. reserves for all fossil fuels (Table 9), and if one considers the present consumption rates (even though these rates are decreasing slightly), the fossil fuel outlook is not particularly encouraging, especially for petroleum. The following chart lists the proved reserves of coal, natural gas, and petroleum not only for the U.S., but also for the world.

Table 9
Proved Reserves of Coal, Natural Gas, and Crude Oil

RESOURCE	WORLD RESERVES	U.S. RESERVES
Coal	788.6 billion short tons	438 billion short tons
Natural Gas	2,639 trillion cubic feet	191 trillion cubic feet
Crude Oil	648.5 billion barrels	26.4 billion barrels

Source: EIA 1980 Annual Report to Congress, pp.42, 121.

The future reality is that utilizing and developing a combination of energy sources is prudent policy as well as a necessity since the U.S. and Nebraska can no longer depend solely (as in the past) upon a fuel source such as petroleum. The remaining proved reserves of petroleum on a national scale number 26.4 billion barrels (which is approximately 30% of the world production.) At current consumption rates, this domestic supply of crude oil would be depleted in approximately 4 years! This alarming calculation assumes that the U.S. would receive no imports during the 4 year period. If the world proved reserves of 648.5 billion barrels were consumed at the apparent consumption rate[3] of 62.84 million barrels per day or 22.9 billion barrels per year, the world supply of petroleum would last only 28 more years!

Diminishing supplies of petroleum would affect all facets of social growth--particularly industrial, agricultural, and economic growth. A cause and effect relationship, somewhat circular, will occur if the U.S. continues to depend upon petroleum to the extent it has in the past. As the petroleum supply decreases, fuel prices will increase. If petroleum, which provides a great share of the nation's fuel supply, begins to diminish (in supply), industrial and economic growth will begin to diminish and will consequently affect agricultural production.

To replace and/or supplement imported and domestic nonrenewable fuels, an alternative would be supplying U.S. and Nebraska petroleum supplies with renewable energy resources, rather than eliminating the supply of fossil fuels. Fossil fuels could be partially replaced or supplemented with these longer lasting and replenishable energy supplies. These supplies should include a combination of energy sources such as solar, nuclear, biomass, and geothermal. Nuclear and solar resources are beyond the scope of this report, but biomass resources which have many energy applications, along with geothermal resources which have a particular application to the ethanol industry, will be discussed.

Biomass is defined as generally any organic substance other than oil, or natural gas. Biomass includes oceanic and terrestrial crops, grain, crop residues, wood, wastes, sewage, and sludge; however, this study will consider crops, crop residues, wood, urban and industrial wastes, cheese whey, organic food wastes, and distressed grains as potential resources for ethanol production. Each resource has either its own potential benefits and potential utilization, or its own restrictions.

Crop Inventory

Before a detailed crop inventory can be discussed, a mention of available land in Nebraska should be made. In 1978, Nebraska had 22.4 million acres in cropland, 22.2 million acres in pastureland and rangeland, 1.7 million acres of woodlands. In all, land in farms[4] totaled 46.3 million acres. In 1981, land in farms numbered 47.6 million acres, whereas the number of individual farms totaled 64,000. These farm and farmland figures may not account for land such as marginal land which might be utilized in crop production, specifically for the ethanol industry; however, the use of marginal land would have several impacts. First, its utilization would increase the price of other good land. Secondly, marginal land would be expensive to use because it is generally harder to cultivate.[5] These impacts need to be considered before utilization solely for ethanol production. It must be noted that the United States Department of Agriculture land set-aside program was abolished for the years 1980-1981. Presently, due to anticipated demand, most farmers are planting all cultivated acres despite the impact this may have on crop prices, which are affected by abundant grain supplies such as those anticipated from the 1981 harvest.

If one were to make a detailed crop inventory of Nebraska, one would also see that Nebraska holds an important position within the total U.S. crop production scope. Out of the fifty states, Nebraska's agricultural contributions are significant; in 1980, Nebraska corn was roughly 10% of the U.S. supply, whereas wheat was 5%, soybeans were at 3%, grain sorghum was 20% of the total production. As far as ranks are concerned, throughout the nation Nebraska ranked 4th in corn production, 10th in soybean production, 7th in all wheat production, 3rd in grain sorghum, 5th in edible dry beans, 6th in sugar beets and 5th in all hay production. Compared with the large 1979 crop production, the 1980 production was lower for some crops (down 16%) due to below normal precipitation and hot weather. In Table 10, the specific crop production over a five year span in Nebraska and the U.S. is apparent.

Table 10
5 Year Crop Production in Nebraska and the United States

CROP	NE 1976	NE 1977	NE 1978	NE 1979	NE 1980	US 1976	US 1977	US 1978	US 1979	US 1980	UNITS
Corn	518.5	648.5	762.8	822.3	822.3	603.5	6,266.4	6,425.5	7,086.7	7,764.8	Mil. Bu.
Soybeans	19.6	40.7	42.5	54.7	53.1	1,287.6	1,761.8	1,870.2	2,267.6	1,817.0	Mil. Bu.
All Wheat	94.4	103.3	81.6	86.7	112.1	2,142.4	2,036.3	1,797.5	2,141.7	2,370.0	Mil. Bu.
Grain Sorghum	119.7	147.0	137.3	144.6	121.8	719.8	793.0	847.8	814.3	588.0	Mil. Bu.
Dry Edible Beans	1.98	1.77	1.95	2.16	2.58	17.8	16.6	19.0	20.7	26.1	Mil. Cwt.
Sugar Beets	1.69	1.35	1.37	1.46	1.78	29.4	25.0	25.7	22.0	23.2	Mil. Ton
All Hay	6.0	7.5	7.5	7.6	7.1	120.0	131.3	142.2	145.9	131.0	Mil. Ton
Potatoes	1.6	1.8	2.1	1.8	2.2	357.8	354.2	365.2	347.6	----	Mil. Cwt.

Source: Nebraska Agricultural Statistics Annual Report 1977/Preliminary 1978; 1978/1979; 1979/1980.

Past and present intended acreages and yield trends can help project future yields. Presently in Nebraska, the 1981 intended acreage for wheat, soybeans, and sorghum, increased, but corn and other crops such as oats, sugar beets, and barley were planted in fewer acres than in 1980. The overall 1981 production is projected to be higher than the 1980 crop year even though most of the U.S. intended acreage for planting decreased by 1% for most crops. This indicates that the yield per acre is projected to be higher than the 1980 crop yield. In fact, the 1981 U.S. corn crop is predicted to be the 2nd largest in U.S. history. The projections which the USDA issued for 4 major crops in 1981 were as follows: corn with 7.725 billion bushels, wheat with 2.703 billion bushels, soybeans at 2.02 billion bushels, and sorghum with 833 million bushels. These figures were calculated from intended acreage and from past yield trends.

Along with the U.S. crop projection, projections were also issued for

Nebraska crops. The 1981 projections have increased yields of corn, soybeans, and grain sorghum from the previous crop year of 1980, but have shown a decrease yield for wheat. Corn should total 759 million bushels.[6] Soybeans should be 73.5 million bushels, and grain sorghum should number 161.95 million bushels. Wheat production should total 103 million bushels.

With large annual supplies of grain being placed in storage after harvest, Nebraska farmers need an active, growing market for their products. In an effort to add stability to an often volatile grain price structure, the Federal Commodity Credit Corporation (CCC) was established. However, despite the goal of adding stability to grain prices, CCC held grain often remains in storage particularly if low grain prices persist for extended periods. Despite relatively low corn production in 1980, the CCC corn reserve in 1981 totaled 27.9 million bushels. Low market prices for corn have kept most of the CCC corn off the market because it is stored at a price which is considerably higher than current country elevator market prices. Because this corn is virtually unsaleable due to current prices, it represents a sizable supply to which additional grain will be added after the 1981 harvest. While normal market conditions would not involve the use of all this CCC stored corn for ethanol production, a reserve of this size does represent a "strategic reserve" of sorts in the event of a sudden liquid fuel supply disruption, which might necessitate distribution of a portion of this reserve to ethanol production. This readily available supply of 27.9 million bushels of corn could be converted to 72.5 million gallons of ethanol and approximately 260,400 tons of distiller's grains. Emergency utilization of the CCC reserve in this manner would help in meeting the liquid fuel shortfall without depriving livestock of the protein they would normally receive from the whole corn.

Nebraska's agricultural crops could provide great additional resources for the ethanol industry--fuel and food. These crops produced in ample supply are either marketed and/or predominately fed to livestock, or stored for future use. If crops are utilized in conjunction with other biomass resources, an effective alcohol production system could develop. Not only would a valuable fuel result from agricultural crop usage, but an important high-protein by-product, which could be used for animal or human consumption, would result, too.

Crops grown in Nebraska such as grains, potatoes, and sugar beets are primarily used as food which contain necessary energy balances of protein, starch, and sugars for human and/or animal consumption. These high-starch content crops could be used in the production of ethanol. Sorghums, sugar beets, potatoes, wheat, and soybeans would be suitable starchy crops for ethanol production, but corn would be the prime contender because of its availability and economic attractiveness. Presently, approximately 90% of all the corn produced in the state is used for livestock feed. (Other corn equivalents, which include grain sorghum, barley, oats, and rye, are also used as feed grains.) A portion of these crops were fed or used on-farm, but a large portion was also sold. The following chart indicates the 1981 production and consumption on-farm in Nebraska as well as the amount sold (Table 11).

Table 11
1980 Production and Consumption of Corn and Corn Equivalents

CROP	NE PRODUCTION*	USED ON-FARM*	SOLD*
Corn	603.50	205.20	398.30
Grain Sorghum	121.80	30.50	91.30
Barley	.95	.57	.38
Oats	15.20	11.10	4.10
Rye	.47	.12	.35

* estimations in million bushels
Source: Nebraska Agricultural Statistics, p. 12.

Any crop which has a high starch content could be used in the production of ethanol. The following chart (Table 12) illustrates potential ethanol production per unit from high starch crops.

Table 12
Conversion Chart For High Starch Crops

CROP	CONVERSION FACTORS			ALCOHOL YIELD
Corn	2.6 Gal/Bu	93 Gal/Ton	237 Gal/Acre	1,569.1 Million Gallons
Wheat	2.6 Gal/Bu	87 Gal/Ton	84 Gal/Acre	291.5 Million Gallons
Grain Sorghum	2.8 Gal/Bu	100 Gal/Ton	146 Gal/Acre	341.0 Million Gallons
Potatoes	1.4 Gal/Bu	29 Gal/Ton	----------	3.2 Million Gallons
Sugar Beets	8.14 Gal/Cwt	27 Gal/Ton	354 Gal/Acre	48.6 Million Gallons
Sweet Sorghum	----------	----------	381 Gal/Acre	----------
Fodder Beets	----------	----------	900 Gal/Acre	----------
		TOTAL POTENTIAL ALCOHOL YIELD		2,253.4 Million Gallons

Source: Ethanol Production & Utilization For Fuel, pp.7,72,81.

Of these high starch and sugar crops, fodder beets, sweet sorghum, and sugar beets have the highest alcohol yield per acre; these crops, if cultivated for the alcohol industry, would be excellent resources. Sugar crops already have sugar in usable form for the alcohol fermentation process. Fodder beets, closely related to sugar beets, have a much greater potential yield per acre than corn or any other crop. Other crops, which are in experimental testing stages, are jerusalem artichokes and high energy sorghum—a hybrid of sweet sorghum and grain sorghum. All of these crops have potentially high alcohol outputs. Unfortunately, the by-products from sugar products contain very little protein; therefore, sugar crops would yield a by-product which would be less valuable than the food by-product from grain. Grain crops, on the other hand, could produce extremely useful high protein by-products and minerals. These by-products could be used as food for livestock and humans.

Resources for Ethanol Production

In addition to the vast and abundant agricultural crop production in Nebraska, several other organic sources surface as possibilities for the alcohol industry. Materials subject to fermentation include crop residues, wood (preferably dry, bark-free), urban and industrial waste products such as city refuse, cheese whey, and organic food wastes, and distressed grains. The following chart (Table 13) displays conversion factors and potential yields of most of these alternative potential energy resources, excluding organic food wastes and distressed grains.

Table 13
Other Potential Resources for Nebraska's Ethanol Industry

RAW MATERIAL	Annual Supply	Conversion Factor	Alcohol Yield
crop residues	27.3 million tons	35 gallons/ton	953.6 million gallons
hay (dry)	7.0 million tons	30 gallons/ton	20.0 million gallons
wood	.37 million tons	50 gallons/ton	18.4 million gallons
(71% lactose) whey solids	.02 million tons	86 gallons/ton	1.42 million gallons
solid urban organic wastes	.4 million tons	30 gallons/ton	11.8 million gallons
		TOTAL POTENTIAL ALCOHOL YIELD	1,005.22 million gallons

Source: "Raw Materials For Fuel Alcohol Production," Ethanol Production & Utilization For Fuel, p. 7.

Crop residues whose major component, cellulose, may be broken down for alcohol production, have potential but perhaps somewhat limited energy uses in Nebraska. Foremost, crop residues make important contributions to the soil by providing protection from water and wind erosion, adding to moisture content, and increasing soil tilth and structure with a supply of nutrients. Removal of these protective residues might cause undesireable consequences to the farmer;

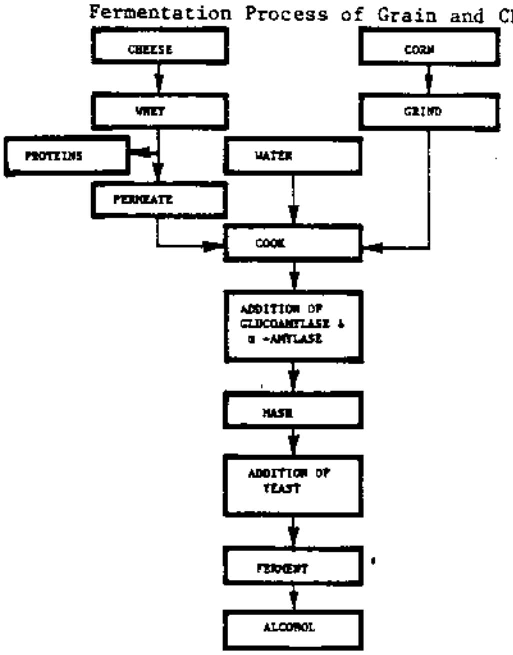
the productivity of the soil would be lessened, and the land would suffer irreversible damage without those residues maintaining and protecting the soil. It is in the best interest of this state to protect the soil whose importance is essential to agriculture; then if surplus residues are produced, these residues may be considered for livestock feed, soil and plant nutrient renewal, and industrial purposes such as ethanol production. In Nebraska, surplus residues are calculated at 7,492,000 tons and are used in ways other than protection from erosion. Nationally speaking, one source projects that the harvestable residues could have the potential to produce 1% to 2% of the energy used in this country.

Another consideration for alcohol production is the hay crop which also contains cellulose; however, this crop, which is tied closely with Nebraska's cattle production, supplies many farmers with a major feed component. In all probability, hay is not a practical consideration for the alcohol fuel industry, unless an excess of hay were produced solely for ethanol production.

Dry wood, another source of cellulose, has the potential to produce 50 gallons of ethanol per ton. Nebraska forests or wooded areas totaling 700,000 acres could produce annually 368,000 tons of dry wood. This annual supply potentially would yield 18.4 million gallons of alcohol. Nebraska is not as ideally suited for producing this biomass resource as other states may be. Due to limited rainfalls and growing seasons, wood production would be restricted; consequently, wood in Nebraska would not be a stable commodity for the alcohol industry.

Regarding waste products, much research and investigation have been conducted at the University of Nebraska concerning the utilization of cheese whey for alcohol fuel. Cheese whey, which contains lactose, can be fermented into alcohol. A Professor of Food Science and Technology at UNL, Dr. Khem Shanani (who has applied for a patent for ethanol production from a combination of cheese whey and grain mixture), presents clearly the potential of whey as a resource for ethanol production. The following figure (Figure 7) graphically depicts the process involved in the fermentation of grain and cheese whey.

Figure 7
Fermentation Process of Grain and Cheese Whey



Source: "Industrial Alcohol Production From Whey and Whey: Grain Mixtures," Ethanol Production & Utilization For Fuel, p.21.

Shahani calculates that nearly 700 million pounds of cheese whey are produced annually throughout the state; of this amount 32.6 million pounds are wasted statewide, whereas nationally, one billion pounds of whey are discarded as wastes which also create industrial economic liabilities and public environmental concern over their disposal. The following chart (Table 14) compares the componental amounts of cheese whey in Nebraska and in the United States.

Table [14]

Annual Supplies of Cheese Whey in Nebraska and the U.S.

NEBRASKA	Annual Supply Production	Supply Used	Supply Wasted
liquid whey	700 million lbs.	130 million lbs.	570 million lbs.
whey solids	40 million lbs.	7.4 million lbs.	32.6 million lbs.
U. S.			
liquid whey	30 billion lbs.	15 billion lbs. *	15 billion lbs.*
whey solids	2 billion lbs.	1 billion lbs.	1 billion lbs.

Source: "Industrial Alcohol Production From Whey and Whey: Grain Mixtures," Ethanol Production & Utilization For Fuel, pp.19,20.

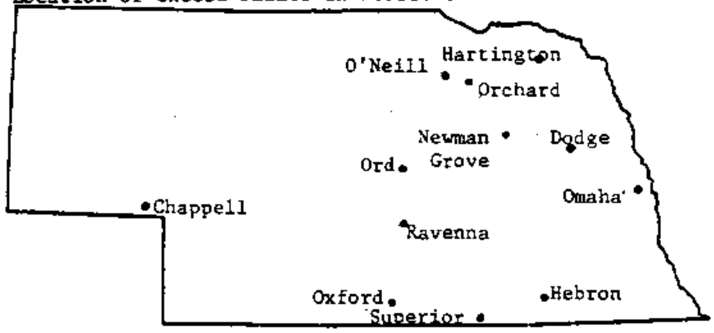
* approximations

From the wasted cheese whey in Nebraska, an estimated 1.0 to 1.4 million gallons of alcohol could be produced even if the process were only 70% efficient. Additionally, the cost per gallon is calculated to be roughly $.90. The use of cheese whey in ethanol production could create another market for the dairy industry, which could also be rid of the economic liability in the disposal of this cheese whey waste.

From an environmental standpoint, utilization of cheese whey would, thus, benefit society by lessening the quantity of waste products. Presently, the Nebraska cheese plants, which produce 700 million pounds of cheese whey per year, could provide their waste products to the ethanol industry. If an alcohol plant were located nearby, the transportation cost of the whey would be minimal, and the availability of a stable commodity could strengthen the alcohol fuel industry. The following map (Figure 8) identifies Nebraska cheese plants.

Another waste product which has been previously overlooked in Nebraska would be organic food wastes supplied from food processing plants. A number of food processing plants are located throughout the state. The wastes from these plants

Figure 8
Location of Cheese Plants in Nebraska



Source: The Ethanol Distilling Industry: An Industrial Opportunity In Nebraska, p. 11.

sometimes have potential sugar contents which could be utilized in ethanol production. For example, onion skins, potato and citrus wastes could be fermented into alcohol. Unfortunately, the exact volume of these wastes (even though these exist) has not yet been determined. The areas surrounding these food processing plants would be ideally suited for alcohol plants; transportation costs of wastes--wastes which would normally procede to landfill--would be minimal. These wastes would also be stable commodities upon which the ethanol industry could depend.

Urban refuse would also be an excellent, readily available resource for ethanol production. Even in a state such as Nebraska whose population is not exceedingly high when compared to its area, its organic solid refuse from the twelve largest cities is estimated at 394,000 tons per year; that is, 4 pounds of wastes per person a day. This refuse, which inevitably ends up in landfill, could be separated relatively easily into organic and inorganic components. Cardboard, paper products, wood, leaves, grass, shrubbery, and food wastes would be collected and processed into alcohol. With a dependable and annually increasing source such as urban waste, the ethanol industry would be amply supplied for alcohol production.

Before discussing another potential resource (distressed grains), another topic, grain storage, needs to be pursued. In Nebraska, the storage capacity as of January 1, 1981, in terms of usable space was 1,006,050,000 bushels for on-farm storage, whereas off-farm space totaled 513,494,000 bushels. The total 1981 usable space, then, equals 1,519,544,000 bushels. Even though the stocks of grain as of January 1, 1981, in storage were great (total on-farm was 534,905,000 and total off-farm 338,587,000 bushels), the estimated 1981 production will add 1.1 billion bushels[7] to these existing stocks and make grain stocks in storage even greater. With liquidated reserves (grain fed to livestock and grain used for other purposes), it is estimated that the excess space in 1981 will be 70,604,000 bushels. If the projected production of 1.1 billion bushels needs an outlet, either a market such as the ethanol industry, or new storage space instate or out-of-state would need to be made available.

With grain in storage for extended periods, one runs the risk of spoilage. Sometimes improper storage conditions can lead to overheating, which causes grain to spoil. The degree of spoilage is important here—if the amount of toxins and/or mold is excessive, the grain may prove to be unmarketable. The crop which is unmarketable due to spoilage or contamination, will be referred to hereafter as distressed grain. Some distressed grain is retrievable for livestock feed, whereas other distressed grain is unpalatably moldy or even harmful to livestock. If this grain cannot be blended or mixed with other feedstocks, then, its worth as a food is nullified.

The percentage of distressed grain, however, is very hard to determine and almost taboo to mention. According to Donald Hanway, an Agronomy Professor at the University of Nebraska, most distressed grain will show forth when it is released from storage. The Cooperative Extension Service verbally estimates that a very small percentage, perhaps 1% or 2% of Nebraska's stored grain, becomes distressed in storage. (Grains held in on-farm storage for longer periods of time.) This low percentage, if accurate, is attributed to storage which is less problematic in Nebraska than in southern or eastern states where more humid and/or warmer temperatures affect grain and create potential stress conditions. On the other hand, this low percentage, if interpreted in terms of bushels-in-storage (January 1, 1981) could be sizable. At a rate of 1%, distressed or out-of-condition grain would be approximately 5.4 million bushels for on-farm storage and 3.4 million bushels for off-farm storage. At 2%, off-farm would total 6.8 million bushels, whereas on-farm would number 10.7 million bushels. These low percentages conflict with those recently issued by the national GAO (General Accounting Office). The GAO reports that about 85% of grain in storage appears storable.[8] The grain in storage was tested, but the exact percentage of non-storable grain was undetermined, except by implication. The implication is that the remaining 15% of grain in storage is contaminated or in bad condition. Since this 15% estimation exceeds the local Nebraska percentage of 1% or 2%, one cannot help but wonder how much grain in storage is actually distressed. Also, if this stored grain were lessened in quantity via another market such as the ethanol industry, would this alleviate quantitative spoilage problems?

Besides storage, conditions for distressed grain depend mainly on a particular year, its weather--rainfall, harvest weather (wet or dry). If the situation arises in which no on-farm or off-farm storage is available, the grain is piled outside and becomes susceptible to (all) weather conditions, infestations, and contamination (dirt, gravel, etc.). Of course, this grain has greater potential to become distressed more quickly. In addition, if harvested wet grain is placed in storage, spoilage is more likely to occur. According to the Lincoln Inspection Service, the outlook for this year's crop is favorable due to rather dry weather.

The problem with distressed grains for the alcohol industry would be the degree of spoilage. If a grain's starch content has entirely fermented and vanished, then it is of no value to an alcohol producer or to a feed blender. There is nothing left in the grain for the fermentation process involved in the production of alcohol. On the other hand, if the degree of disintegration is minimal, this grain could be a valuable resource for alcohol. When considering the use of distressed grains for the production of alcohol, ethanol producers must evaluate the degree of spoilage—the profitability of extracting the already fermenting starch; the less starch one has, the less alcohol one produces.

The availability of distressed grains is another factor which would affect the ethanol industry. The annual location for distressed grain would change due to weather conditions. Because of this changing location, the varying availability, and differing degrees of spoilage, distressed grain would not be a dependable source for one particular alcohol plant in a given year, unless the distressed grain in storage would remain constant year after year. Even though the supply would be inconsistent, it could be utilized if provided to the alcohol industry. In this case, the farmer with distressed grain could benefit, particularly if he/she were unable to find another market for the product.

Another possible resource comparable to distressed grains for the ethanol industry would be out-of-date seed corn. According to the State Gasohol Committee, calls have been received concerning sizable amounts of seed corn which can no longer be planted. Since treated seed corn cannot be fed to livestock, it often ends up in a landfill which presents an environmental concern and often an influx of rodents. Rather than going to a landfill to dispose of this potential environmental problem, the out-of-date seed could be used in the production of ethanol. Just as distressed grain, outdated seed would not be a stable commodity for the alcohol industry because its availability would vary from year to year; outdated seed corn is mentioned because it also could be utilized if provided to the industry and in isolated cases, is currently being utilized in Nebraska ethanol plants.

In summation, crop residues, hay, and wood, would not be realistic feedstocks for the Nebraska ethanol industry, unless these were grown extensively and specifically for the production of alcohol. Distressed grains and outdated seed would be available each year in varying quantities. On the other hand, cheese whey, collectable urban wastes, and wastes from food processing plants could function as stable commodities for ethanol production. The greatest advantage of utilizing these waste products would be their dependability as alcohol feedstocks. Processing wastes would not only benefit and clean up the environment, but would also help to conserve our diminishing, yet priceless nonrenewable resources such as fossil fuels, as well as to provide the alcohol industry with a dependable commodity from which ethanol may be derived. If waste products are used to produce ethanol along with agricultural crops, the combined production will benefit industry, the farmer, and the environment. Below is a review chart (Table 15) containing conversion figures, potential yields, and annual supplies of resources for the alcohol fuel industry.

Table 15
Review Conversion and Potential Yield Chart for Nebraska

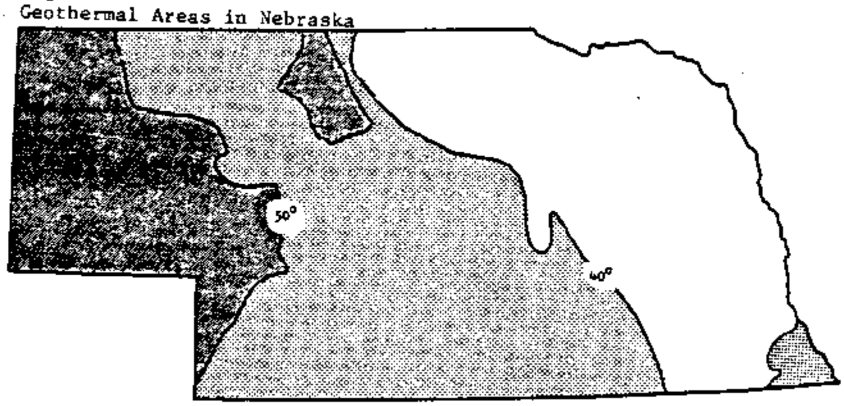
RAW MATERIAL	1980 SUPPLY	CONVERSION FACTORS			ALCOHOL YIELD
Corn	603.5 Million Bushels	2.6 Gal/Bu	93 Gal/Ton	237 Gal/Acre	1,569.1 Million Gallons
Wheat	112.1 Million Bushels	2.6 Gal/Bu	87 Gal/Ton	84 Gal/Acre	291.5 Million Gallons
Grain Sorghum	121.8 Million Bushels	2.8 Gal/Bu	100 Gal/Ton	146 Gal/Acre	341.0 Million Gallons
Potatoes	.11 Million Tons	1.4 Gal/Bu	29 Gal/Ton	------------	3.2 Million Gallons
Sugar Beets	1.8 Million Tons	8.14 Gal/Cwt	27 Gal/Ton	354 Gal/Acre	48.6 Million Gallons
Sweet Sorghum	--------------------	----------	----------	381 Gal/Acre	--------------------
Fodder Beets	--------------------	----------	----------	900 Gal/Acre	--------------------
Crop Residues	27.3 Million Tons	----------	35 Gal/Ton	------------	953.6 Million Gallons
Hay (dry)	7.0 Million Tons	----------	30 Gal/Ton	------------	20.0 Million Gallons
Wood	.4 Million Tons	----------	50 Gal/Ton	------------	18.4 Million Gallons
Whey Solids	.02 Million Tons	----------	86 Gal/Ton	------------	1.42 Million Gallons
Solid Urban Organic Wastes	.4 Million Tons	----------	30 Gal/Ton	------------	11.8 Million Gallons
			TOTAL POTENTIAL ALCOHOL YIELD		3,258.62 Million Gallons

Source: Ethanol Production & Utilization For Fuel, pp. 7,72,81

Geothermal Resources

Geothermal energy could provide a variety of usages; most importantly, geothermal energy is a potential resource in ethanol production. Since a large part (67%) of Nebraska rests over potential geothermal resources (temperatures greater than 40°C at a depth of 1 kilometer) and since some areas in western Nebraska possess temperatures from 70°C to 105°C at depths of 1.3 to 1.5 kilometers respectively, these water temperatures could be used directly or indirectly in many phases of ethanol production. The following map displays the geothermal regions underlying Nebraska (Figure 9).

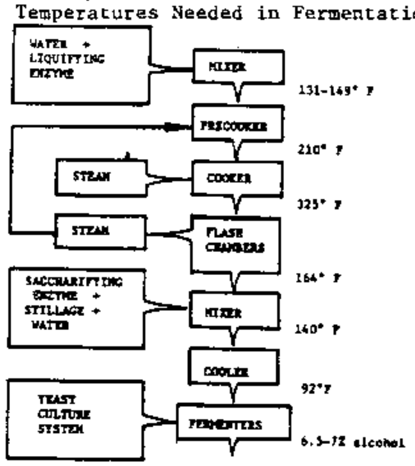
Figure 9
Geothermal Areas in Nebraska



Source: Gosnold, p.12.

High temperatures from the warm deep water which would be pumped from and replaced back into the earth could, in fact, supply or help supply, by means of an additional heater, the necessary temperatures at different phases used in the fermentation process. The following diagram (Figure 10) indicates some of the necessary temperatures at different phases of fermentation and distillation.

Figure 10
Temperatures Needed in Fermentation



Source: <u>Ethanol Production & Utilization For Fuel</u>, p.18.

Geothermal energy could supply a significant amount of the heat energy used in cooking grain mixtures and other biomass feedstocks. Geothermal energy could be made easily available to the synthetic fuel industry, if the usage of the aforementioned resources were developed.

Ethanol Production

A primary application of biomass would be in the production of ethanol—an alternative fuel. This alternative, yet not new liquid fuel, could be used as a replacement for or a supplement to petroleum. Since ethanol can be utilized by itself or in a combination of fuel mixtures, its utilization depends upon widespread production and availability. Gasohol and diesohol, which are available mixtures of 10% alcohol and 90% petroleum, are sold across the nation, but are not utilized as much as the traditional fuels, gasoline and diesel. For example, gasohol sales, particularly in Nebraska, which have definitely increased in usage during the past two years (Table 16), only equal 4% of gasoline sales instate.

Table 16
Gasohol Sold in Nebraska

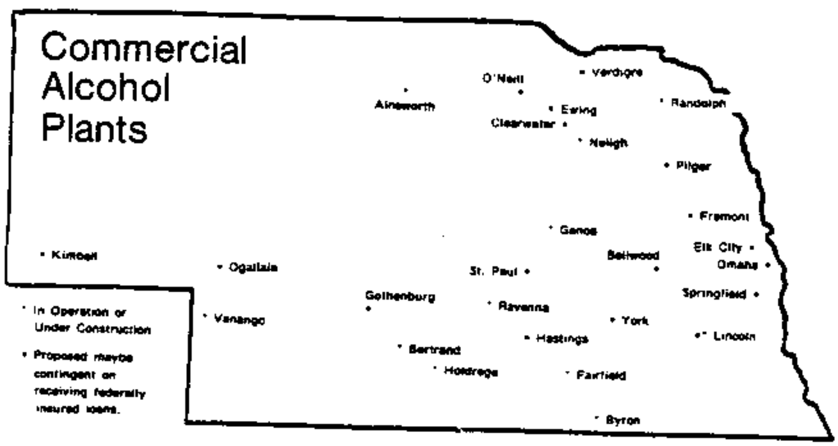
	TOTAL SALEABLE GASOHOL
1979	8.013 million gallons
1980	32.874 million gallons

Source: Courtesy of the Nebraska Gasohol Committee.

To aid the availability of gasohol, ethanol production is already underway in Nebraska. In fact, there are currently 13 operational alcohol plants throughout the state, as well as 12 experimental or prototype stills. Most of these operating plants produce alcohol of 190 proof or less; one plant is currently producing 200 proof or anhydrous alcohol, and is involved with upgrading lower proof alcohol to 200 proof. These stills produce or have the capacity of producing a total of approximately 3,438,750 gallons per year.

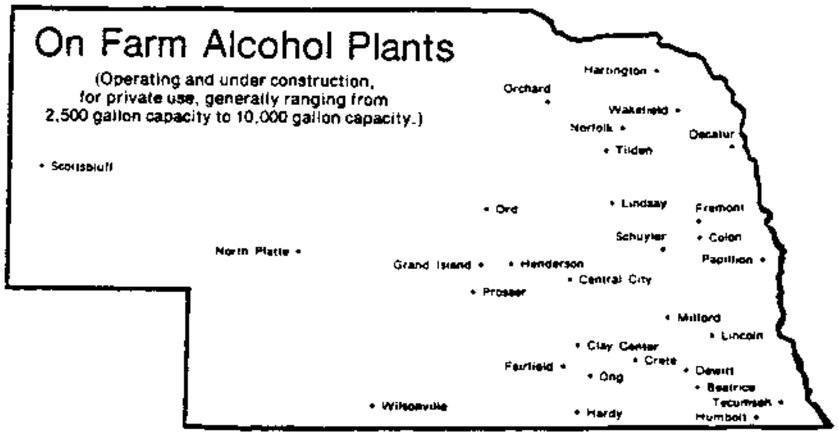
Plants under construction, proposed, and plants built but not yet operational total 24 of which number, 18 will produce 200 proof alcohol, and 6 will produce 190 proof or less. The production capacity is projected at approximately 663.1 million gallons per year. This projected production is highly unlikely and unrealistic due to difficulties in obtaining public financing. If this projected total for the not yet producing plants were combined with the production capacity of the producing plants, the total would be 666.5 million gallons per year--an unlikely production volume. In addition, there exist some Nebraska plants, operational and proposed, whose production is not specified; these plants could very well be on-farm stills or experimental stills. Pictured below are two maps of Nebraska (Figure 11 and Figure 12). These maps which display the operating and proposed alcohol plants, whether commercial or on-farm, indicate the widespread ethanol industry in the state.

Figure 11
Commercial Alcohol Plants in Nebraska



Source: Courtesy of the Nebraska Gasohol Committee.

Figure 12
On-Farm Alcohol Plants in Nebraska



Source: Courtesy of the Nebraska Gasohol Committee.

When pure or anhydrous ethanol as well as lower proof ethanol is used, the energy content is not as high as petroleum products such as gasoline or diesel fuels; however, the following chart (Table 17) lists in terms of Btu's the energy content of fossil fuels, ethanol and combinations of the two fuels.

Table 17
Fuel Energy Content

FOSSIL FUEL	Btu/Gallon	BIOMASS FUEL	Btu/Gallon	COMBINATION FUEL	Btu/Gallon
Gasoline	124,000	Anhydrous Ethanol	85,000	Gasohol	120,000
No.2 Diesel	140,000	190 Proof Ethanol	81,000	Diesohol	134,000

Source: "Ethanol---A Fuel For Agricultural Engines," Ethanol Production & Utilization for Fuel, p. 55.

From this chart (Table 17), one can see that the energy contents of ethanol and fossil fuels greatly differ, but the energy content of gasohol and diesohol fuels are closely related to fossil fuels in terms of Btu's. Fossil fuels will have higher Btu ratings than combination fuels, but when fossil fuels are combined with 10% ethanol (as in the case of gasohol), the overall octane rating increases. An increased octane rating often results in better performance for vehicles.

For the past three years, gasohol has been available in Nebraska. Unfortunately, gasohol sales have not been as successful as possible due to distribution problems, supplies of ethanol, and prices much higher than gasoline. Most recently, a gasohol marketing study,[9] which outlines marketing difficulties and proposes some recommendations, has been completed. So far in 1981, gasohol sales have averaged 2.7 million gallons per month and comprise approximately 4% of Nebraska's petroleum sales. Presently, there are 3 ethanol producers[10] serving Nebraska.

By-Products

If a full scale ethanol program were implemented, many useful products[11] could be made available to the American public and to people around the world. Besides producing billions of gallons of liquid fuel, the alcohol industry would supply a by-product which could be used as food, not only in the U.S., but abroad as well. Whole stillage or distiller's grain is a by-product of the alcohol fermentation process. This stillage contains nutrients, yeast cells, coarse grains, and water. In fact, stillage can be separated into 4 main products: condensed solubles (CDS), dried solubles (DDS), distiller's dried grains (DDG), and/or distiller's dried grains plus solubles (DDGS). Even though these products contain very little or no starch, they do possess fat, fiber, and protein--important food requirements for animals and humans. Distiller's grains also have high contents of vitamin B, and phosphorus which happens to be one of the most expensive mineral additives for feed.

Of the whole grain which is converted to ethanol, approximately one third of the matter remains in the form of whole stillage; the other two thirds are equally divided between ethanol and carbon dioxide. For example, a 10,000 bushel batch of corn would yield approximately 180,000 pounds (26,000 gallons) of ethanol, 193,000 pounds of CO_2, and 186,600 pounds of DDGS. The DDGS contains all the protein of the whole grain, but the bulk has been reduced by two thirds to yield a by-product which is approximately 28% protein.

Research conducted at the University of Nebraska has shown tremendous potential for utilizing DDGS as a protein and energy source in livestock feeding rations. While swine and poultry may be able to utilize distiller's grains in limited amounts, the greatest potential is in feeding this product to beef and dairy cattle--ruminant animals. These ruminant animals can more efficiently incorporate the protein contained in DDGS. At the University of Nebraska, these by-products were tested alone and with additives against traditional feeds such as soybean meal. The tests, in most cases, showed that if the grains and solubles were used separately or supplemented with urea (nitrogen supplement), hay, and/or other ingredients, their values as feed were 1.5 times greater than that of soybean meal.[12] These tests did, however, suggest that DDG could be fed to cattle and the DDS could be fed to swine and poultry for best results. Since pigs are not able to digest large quantities of fiber, DDG which is high in fiber and protein is not a suitable feed component. On the other hand, solubles can supply vitamins.

Since beef cattle and dairy cattle have high protein requirements, protein supplements are a great part of the total feed costs. When compared with soybean meal, various combinations of distiller's grains and additives were more economical to feed to growing beef cattle. Distiller's grains also could supply dairy cows with high protein needed for milk production and would also add fat and fiber contents which could lessen milk fat depressions.

Distiller's grains and solubles need not be separated; whole stillage may be fed to livestock, but it must be properly supplemented. Animal science nutritionists suggest that if whole stillage is fed to cattle, dry hay should also be fed. In the case of swine, whole stillage needs some dry grain with additional amino acid supplements which contain lysine and tryptophan, but whole stillage is not recommended for poultry.

Many markets can utilize or have the potential to utilize distiller's grains in different forms--wet or dry. Since Nebraska is a major producer of livestock, the feed industry could profit greatly from the by-products of alcohol production. These high protein distiller's grains and solubles could be fed or mixed with other feed ingredients. Ruminant animals (beef cattle and dairy cows), swine, and poultry would benefit from high protein feed and solubles as additives.

Throughout the nation in 1980, Nebraska ranked 2nd in cattle on feed (1.6 million), 6th in hogs and pigs (3.9 million), whereas dairy cows numbered 1.2 million, and poultry totaled 4 million animals. All these animals could utilize, in one form or another, by-products from ethanol production. (See Appendix I and II for regional livestock production.)

Dried distiller's grains, which are more easily transported than wet stillage, also have potential export opportunities abroad. Presently the U.S. exports a dried pellet product from Archer Daniels Midland Company (ADM). This pellet produced and dried from distiller's grains can be utilized in livestock feed rations.

In addition to livestock feed, distiller's grains have other nutritional marketing potential. The DDGS (distiller's dried grains with solubles) have been successfully fed to dogs and could be additives to pet food rations, without economic loss. Commercial fish feeders presently use distiller's solubles as primary food ingredients in, for example, catfish and trout food formulation. Another potential food market would be human consumption of DDG; distiller's grains add a desireable crunchy texture to food.

Presently distiller's dried grains (DDG) and solubles are available on the ingredient market. In fact, price quotations from 5 cities--Atlanta, Buffalo, Boston, Chicago, and Memphis, are regularly published for these feed ingredients. When comparing prices on the closest market to Nebraska (Chicago), distiller's dried feed at $149 per ton was cheaper than soybean meal at $204 per ton. Distiller's dried feed would be a more economical feed than soybean meal in many cases.

Since there is a great deal of water in distiller's grains, the problems of storage and transportation arise. Unless dried, wet grains will spoil rapidly in storage, especially in hot weather. If this spoiled grain is fed to livestock, serious digestive upsets can occur. In cold weather, there would be problems of keeping wet grains from freezing. The amount of energy needed to dry wet distiller's grains, constitutes about 40% of an alcohol plant's energy. In some cases, the drying process might be necessary for storage or transportation problems. Dried grains would alleviate the rapid spoilage potential of wet grains and would be more convenient to transport.

Feeding wet grains is an advantage to small, on-farm alcohol operations since transportation would be eliminated. Larger alcohol plants may have storage problems with larger quantities of distiller's grains. In this case, drying the mash might be the only solution to spoilage.

As far as transportation is concerned, wet grains are certainly bulkier and heavier than dried grains; consequently, it would be more difficult to move wet grains from place to place. If an alcohol plant were ideally situated next to a feed yard, transportation of wet grain would not be a problem, per se. The feed blender would then have the responsibility of processing the distiller's grain in a suitable way whether or not drying, mixing or storing were involved.

Another marketable by-product from alcohol production would be the colorless nontoxic gas, carbon dioxide (CO_2). In fact, the market possibilities for CO_2 are numerous. The major industrial consumer would be food and kindred products. CO_2 can be used in economical and higher quality freezing, cooling, preserving, chilling of fresh and frozen food; CO_2 can even be used commercially as an immobilizing agent in animal slaughter for the meat packing industry. The beverage industry consumes large quantities of CO_2 for soft drinks, wine, and beer brewing. In Nebraska, 383 food related industries exist--meat packing plants, ice cream and frozen desserts, frozen fruits and vegetables, beverages, bottled and canned soft drinks. The following chart (Table 18) indicates the number of Nebraska establishments which utilize or could utilize CO_2 on a great scale.

CO_2, which sells for \$35 to \$40 per ton, is a relatively inexpensive gas

Table 18
Potential Markets in Nebraska for CO_2

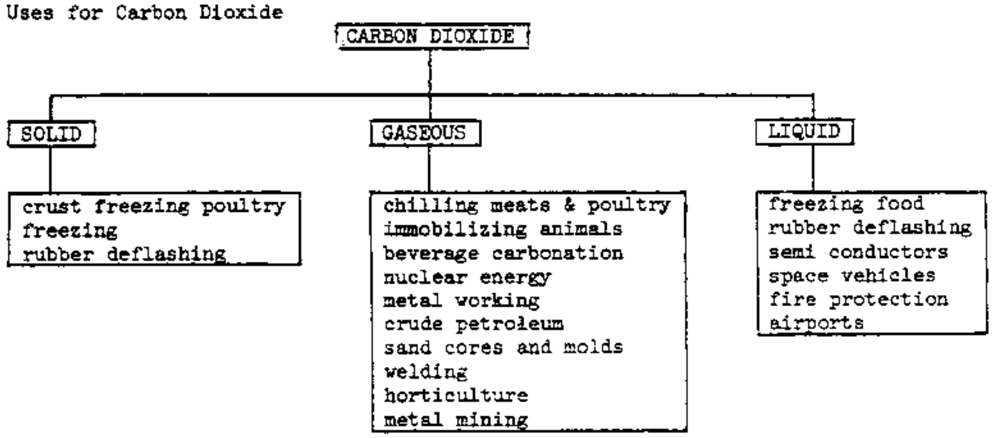
INDUSTRY	
Oil and Gas Extractor	77
Rubber and Miscellaneous Plastic Products	46
Primary Metal Industries	26
Food and Kindred Products	383
TOTAL ESTABLISHMENTS	532

Source: "The Market Opportunity Analysis of CO_2 Part II: Market Profiles," pp. 4,5.

when compared to other gases and chemicals. Unfortunately, the largest drawback to widespread CO_2 production and distribution are containment facilities, which Nebraska presently does not have. This means that all the CO_2 consumed instate has been imported. On the other hand, a widespread ethanol program in Nebraska could supply the product at a relatively low cost with containment facilities.

Some markets which would be potential users of great quantities of CO_2 are oil well stimulation, hydroponics, extraction of oil from seeds, and mechanisms which control or limit dust explosions. In addition, the metal industry could also use CO_2 as a shielding agent in welding. In effect, many industries and markets could benefit from the CO_2, alcohol by-product as Figure 13 indicates.

Figure 13
Uses for Carbon Dioxide



Source: "Market Opportunity Analysis of CO_2 ; A Byproduct of the Grain Distillation Process," p. 14.

Since the Midwest produces most of the nation's agricultural and animal products, it would be an ideal place for potential markets and consumers. If Nebraska, which is centrally located in the U.S., started a widespread production of alcohol, distiller's grains, and other by-products, it could supply major midwestern markets and other centers such as Chicago, Kansas City, Denver, Minneapolis, and St. Louis within a time frame of one day. These centers could be reached by truck, train, airline, and/or barge. Interstate 80 crosses Nebraska east and west, while I-29 extends through the eastern state border, and I-25 rests near the western border of the state. In addition, 9 major airlines and railways are located instate; the airlines include Air Wisconsin, American, Braniff International, Eastern, Frontier, Republic, TWA, Ozark, United, whereas the railroad systems are Burlington Northern; Chicago and North Western; Chicago, Milwaukee, St. Paul, and Pacific; Chicago, Rock Island, and Pacific; Illinois Central; Missouri Pacific; Norfolk and Western; Santa Fe; and Union Pacific. Full shipments transported by rail or barge would be most economically carried. In fact, on the Missouri River, the economic benefits may average as much as $3 per ton.

Tax Incentives

A brief summary of Federal tax incentives for producers and blenders of alcohol fuels is included in this report. The Public Law established to encourage the use and manufacture of alcohol fuels[13] and blends is called the Crude Oil Windfall Profit Tax Act of 1980. The Act provides incentives in the form of tax exemptions and credits. First of all, gasoline blends with at least 10% alcohol (gasohol and diesohol) are exempt from the 4¢ per gallon Federal Excise Tax. Refunds are also available for those who have previously paid excise tax on these specified fuel blends. Secondly, new income tax credits are available to blenders of gasohol/diesohol and to users of straight alcohol fuel. This income tax credit, which is taxable and nonrefundable, is broken down as follows: 40¢ per gallon credit for at least 190 proof alcohol and 30¢ per gallon for at least 150 to 190 proof alcohol. In addition, another 10% tax credit called the Energy Investment Tax credit can be obtained for equipment which converts biomass into alcohol fuels. This tax credit also covers equipment--boilers, burners, or any equipment related to pollution control.

Besides blenders and users, other businesses may benefit from tax exemptions. In order to encourage industrial development, there also exists a tax exemption for qualified industrial bonds which would finance alcohol fuel facilities. A business which is searching for tax exemptions may wish to consider the alcohol fuel related industrial investment.

In addition to the Federal tax incentives, tax incentives are also available at the state level. In Nebraska, three types of tax credits can be obtained. A state motor fuel tax exemption of 5¢ per gallon can be claimed for (at least 190 proof) alcohol and gasoline blends. Users of pure alcohol as motor fuel can also apply for the "special fuels" tax reduction of 5¢ per gallon. In addition, a sales tax exemption or refund can be issued for equipment and energy related construction. Most recently, the Economic Recovery Tax Act of 1981 was passed for the reduction of individual and business income taxes. Businesses, in particular, will reap depreciation deduction benefits from investments made after 1980. These deductions should stimulate, in turn, capital investments, which are made by business, and should help stimulate the faltering American economy.

In Nebraska, potential fuel producers and blenders, and marketers may consult the Nebraska Gasohol Committee at 301 Centennial Mall, Lincoln, 68509. This committee was instituted to aid private industry in establishing a grain alcohol industry in Nebraska. More information about alcohol fuel tax laws may be obtained from a copy of Public Law 96-223 or through one's senator at the United States Senate, Washington, D.C., 20510.

Financing Available for the Ethanol Industry

Public financing could potentially provide funds to future producers of ethanol. Within a financial framework, at least two types of financing surface as possibilities for a business--venture financing and financing of a going concern. Venture financing would be available to businesses without an operating history, such as the ethanol industry, which is relatively new. On the other hand, very little venture capital is readily available in Nebraska from the conservative investment market. Before a commitment of funds, investors need historical operation information, proven technology, balance sheets to support new debts, and earnings which could support stocks. In short, public financing does not appear to be encouraging for the potential ethanol producer or blender in Nebraska.

Since tax breaks would provide incentives to existing businesses, potential marketers and blenders of alcohol fuels might find established companies with available resources. If a private business is in need of a tax write-off, support of an ethanol plant might be a viable option. These private businesses usually have a greater resource base for funding alcohol related projects.

Another option in the form of a tax break could come from the public sector, the community. A municipal bond, if secured, appears as an attractive investment to potential stockholders. If an ethanol industry is supported in this "public" fashion, its stocks purport strong community support and usually have greater potential to be purchased by the investment community.

Additionally, government loans or loan guarantees could be made available to the alcohol industry. Loan programs often assist the capital formation process but may also entail various restrictions, which are not encountered in private acquisition of funds. Understandably, this kind of government guarantee is attractive to some companies, but others may find unexpected delays intolerable during project development. On the other hand, investors may find government guaranteed projects attractive because of the possibility that their risk has been minimized.

Ethanol Production Analysis

In the event of petroleum supply disruption, a major consideration will be the speed with which alternative fuels can contribute to the supply. Conversion of existing facilities for ethanol production would be a practical and economical alternative which has the potential, in many cases, to be "on line" sooner than a new facility. In fact, a feasibility study concerning the conversion of existing sugar beet facilities has been completed.[14] Based on this recent study, it appears feasible from economic and technical standpoints to convert existing sugar beet plants and facilities to adequate facilities for ethanol production. Presently, there is concern over falling sugar beet prices due to cheaper sugar from corn (fructose) and imported sugars. To avoid an economic loss for the farmer, another market such as the ethanol industry could provide an attractive market for sugar beets, which would have high alcohol output. This new market would also offer appeal to Nebraskans since sugar beets are a major crop in the Scottsbluff area.

For persons interested in producing alcohol fuels, the State Gasohol Committee has extensive lists of plant equipment, supplies, manufacturers, engineering firms, and consultants. The Committee also has some technical information on engine conversions to anhydrous alcohol fuel; however, after the promotional Independence Day Alcohol Fuels Race Classic, which will be held July 4, 1982 in Lincoln, Nebraska, an extremely useful and informative manual of different engine conversions will be compiled for public use. Additionally, some local community colleges and technical schools have information about engine conversions. Information about these resources is available through the Nebraska Gasohol Committee office.

Economic Growth and Jobs

If Nebraska were to implement an extensive and increased ethanol production program, the new jobs and products would greatly benefit people in all professions--farmers, feed marketers and producers, petroleum marketers, and related industries. Since new industry is encouraged in Nebraska, an industrial opportunity such as the ethanol industry could provide welcomed statewide economic growth by creating jobs and marketable products. One state, Michigan, has already examined the potential job opportunities involved with an implemented ethanol program.

According to a Michigan study, the development of the alcohol industry would bring healthy economic growth. The development of a domestic alcohol industry would introduce new jobs and new products, particularly alcohol fuel, and could help strengthen the American economy. Production of ethanol would lessen the country's dependency upon foreign oil and would keep American dollars working in the economy. This study also states that new American jobs could sharply increase from the development of a domestic alcohol industry. With an annual production of 6 billion gallons of alcohol, an investment of $12 billion in the ethanol industry could create 960,000 new jobs. The following chart (Table 19) provides the labor breakdown.

Table 19
New Jobs With An Implemented Ethanol Industry

Construction	160,000 jobs	ANNUAL ETHANOL OUTPUT 6 billion gallons
Industrial	210,000 jobs	
Operation and Maintanance	71,000 jobs	
Wholesale & Retail Services, Trade, Transportaion	39,000 jobs	
TOTAL NEW JOBS	960,000 jobs	TOTAL INVESTMENT $12 billion

Source: "American Jobs From Alcohol Fuel," pp.3,5,6.

However, this domestic industry could indirectly affect other existing markets such as corn and sugar sweeteners. If the starch or sugar crop, which is currently supplied to other industries, is utilized for alcohol production, shortages of a particular crop such as corn could possibly cause prices to increase. On the other hand, an implemented ethanol program could greatly aid traditional markets such as livestock feed marketers. The protein by-product from alcohol production is an excellent feed supplement or as feed by itself. In order to decrease the risk of domestic crop shortage and higher prices, a gradual production of ethanol should be implemented.

Additionally, the study suggests a crop breakdown for the ethanol industry; 2/3 of production should come from major feedstock grains such as corn, wheat, and grain sorghum. The remaining 1/3 production would be derived from sugar crops, cull potatoes, biomass wastes and municipal wastes; however, the by-products would not be as useful as the ones from the major feedstock grains. If these agricultural crops were "properly" supplemented with substantial amounts of waste products and cellulosic material, both of which have potential outputs greater than 6 billion gallons per year, ethanol production has a greater potential to be successful without disrupting traditional markets.

Summary

Since Nebraska needs to import approximately 95% of its energy (oil, gas, and coal), a disruption in imported fuel could devastate its economy. Because of its central location, Nebraska would be dramatically affected by a fuel supply disruption, as in 1979. The petroleum supply disruption of 1979 alerted Nebraskans to the potential occurrence of economic, industrial, and agricultural hardship. If domestic nonrenewable fossil fuels were supplemented or even replaced by an alternative fuel such as ethanol, Nebraska's dependence upon imported fuel would decrease, and the risk of economic disruption, particularly in agriculture, would be lessened. An implemented alcohol fuels program could alleviate potential fuel shortages, strengthen the economy, and supply useful fuel and by-products. A combination of energy sources is an extremely prudent policy especially for a state with an approximate 5% net energy production.

Since Nebraska is a major agricultural state, agricultural resources are in plentiful supply for large scale ethanol programs. The corn crop of 1979 as well as the projected corn harvest for 1981 are record high productions in Nebraska and the U.S. Due to present government markets and large annual supplies of corn and other crops in storage, the 1981 projected production may depress Nebraska's agricultural economy unless crop prices improve, or another timely market such as the ethanol industry creates demand for the excess grains.

Other biomass resources, which could provide large amounts of alcohol fuel, could supplement alcohol produced from grain. Many "waste" products such as cheese whey, citrus scraps, cull potatoes, any organic refuse from food processing plants, urban wastes, or forestry products could provide feed stocks for alcohol. The utilization of "wastes" displays ecological responsibility as well as ingenuity in supplying an alternative, renewable fuel. These ample resources need to be explored by potential alcohol producers.

Grain alcohol programs are ideally suited for grain producing states. The advantage to utilizing grain in alcohol production would be the useful by-products --distiller's grains, solubles, carbon dioxide, and fusel oil. Markets for these by-products in Nebraska have great potential. Since Nebraska is a major producer of livestock, the livestock feed market could combine distiller's grains and solubles into feed for cattle, dairy cows, swine, and poultry. Pet food, fish food industries, and a human food market could also utilize these by-products. Carbon dioxide could be marketed to numerous industries instate, whereas fusel oil could be marketed as solvents or for the cosmetic industry.

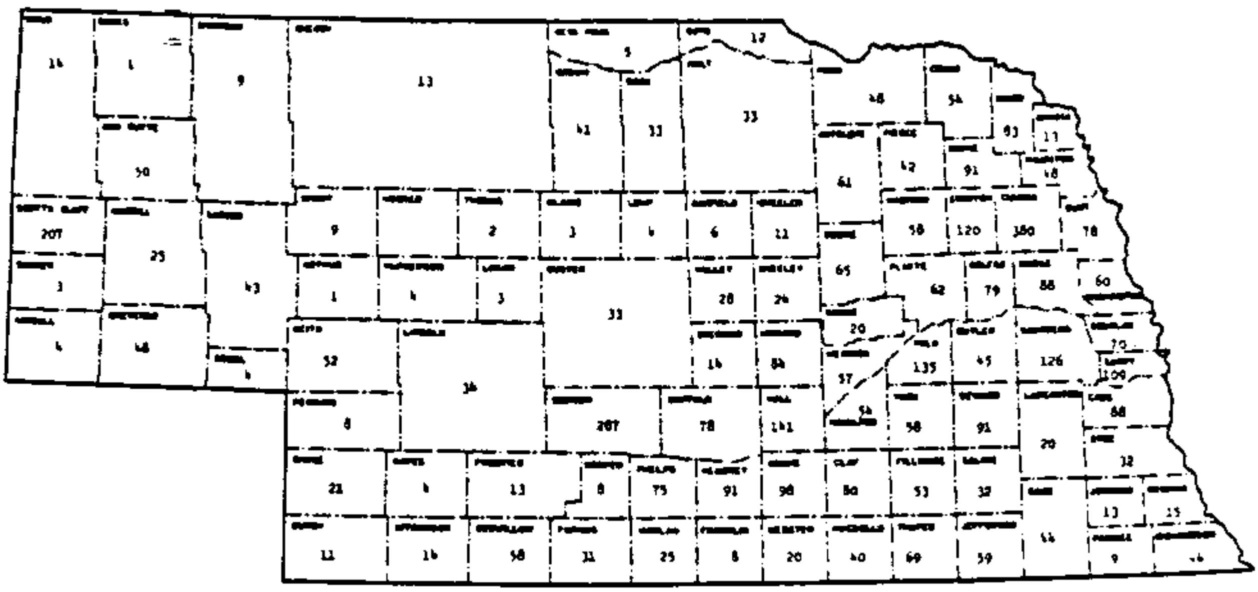
Ideally suited locations of ethanol plants could benefit other industries. If ethanol plants were situated near feed blenders, major livestock feed producers, or areas with large livestock production, transportation of distiller's grain and solubles would be minimized. If ethanol plants were located near food processing plants such as cheese plants, the "waste" products with relatively low transportation costs could be utilized for ethanol production. In effect, location could cut transportation costs considerably.

As far as development of an ethanol program is concerned, the rate of growth is slowly increasing. Gasohol (a combination of gasoline and ethanol) sales, which exemplify this rate of growth, increased 300% from 1979 to 1980. There are also a number of state and Federal tax incentives which indicate strong support for development of an ethanol program. Additionally, recent feasibility studies have demonstrated the feasibility for conversion of existing sugar beet processing facilities to accomodate ethanol production. Perhaps further detailed investigation of the ethanol industry is needed on an economic level or at a technological level. In any event, development of an alternative fuel such as ethanol is a "must" for this state and for the nation to meet future energy demands.

APPENDIX I

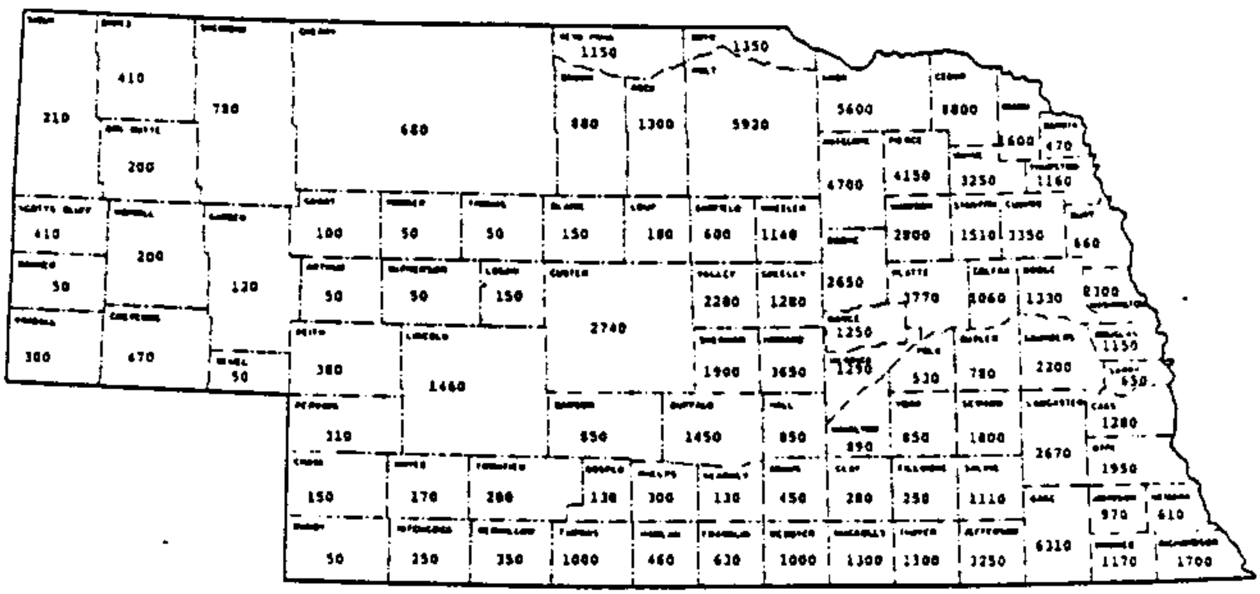
Locations of Cattle and Dairy Cows in Nebraska

Cattle on Feed in Nebraska, 1978 (thousand head)



Source: "The Ethanol Distilling Industry: An Industrial Opportunity in Nebraska," p. 14.

Dairy Cows in Nebraska, 1978

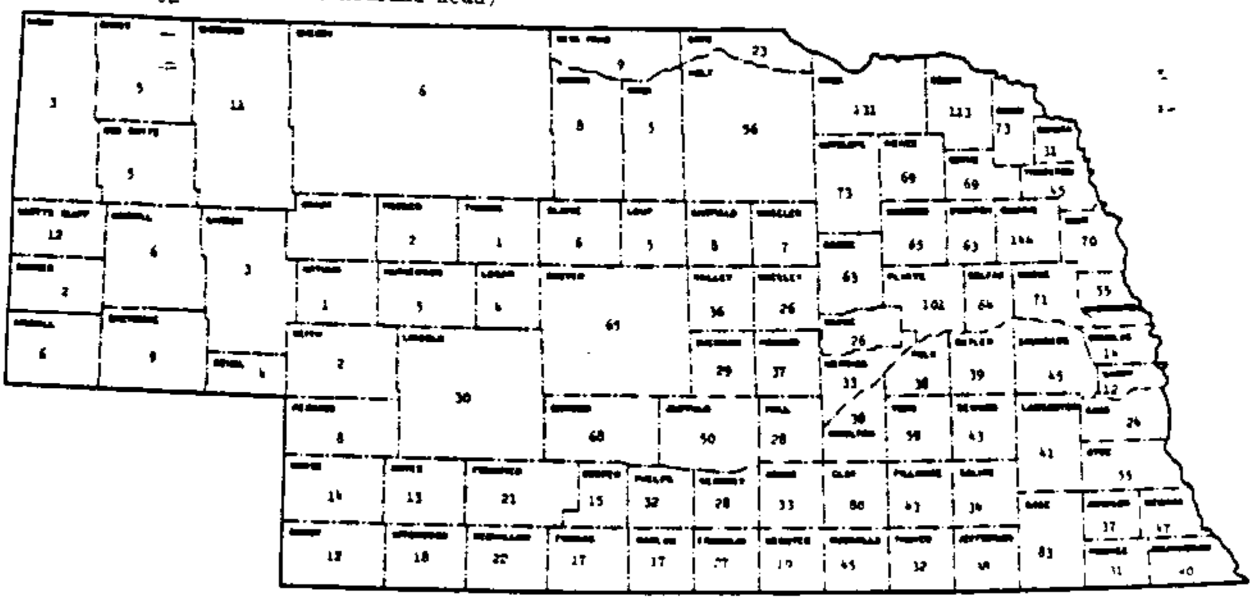


Source: "The Ethanol Distilling Industry: An Industrial Opportunity in Nebraska," p. 15.

APPENDIX II

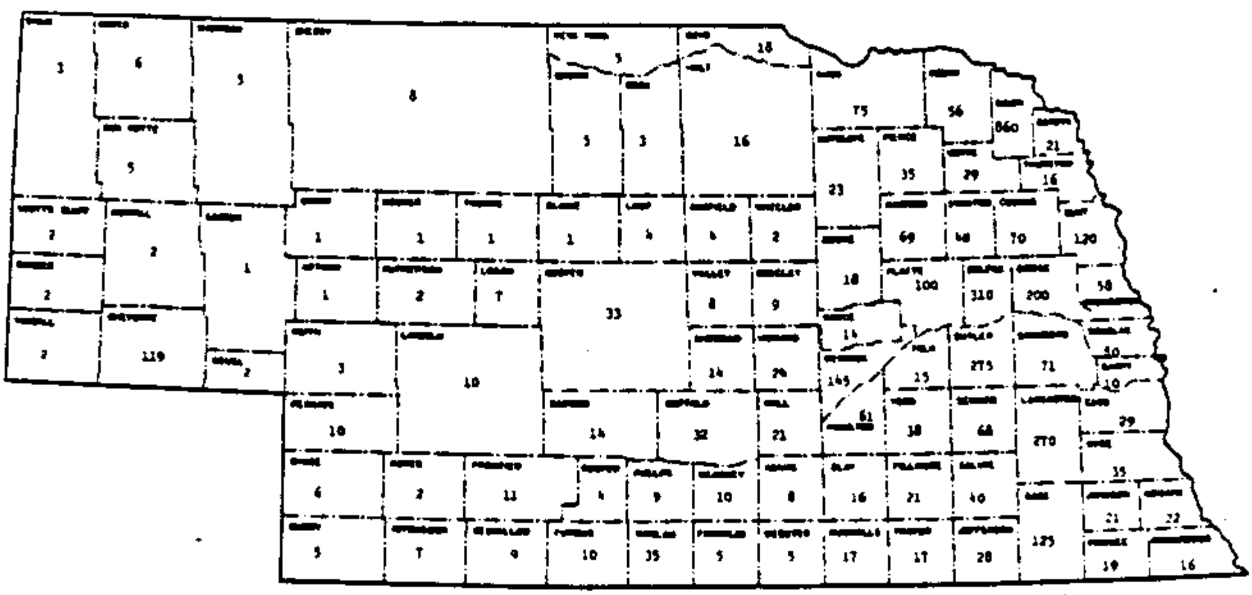
Location of Swine and Poultry in Nebraska

Swine in Nebraska, 1977 (thousand head)



Source: "The Ethanol Distilling Industry: An Industrial Opportunity in Nebraska," p. 14.

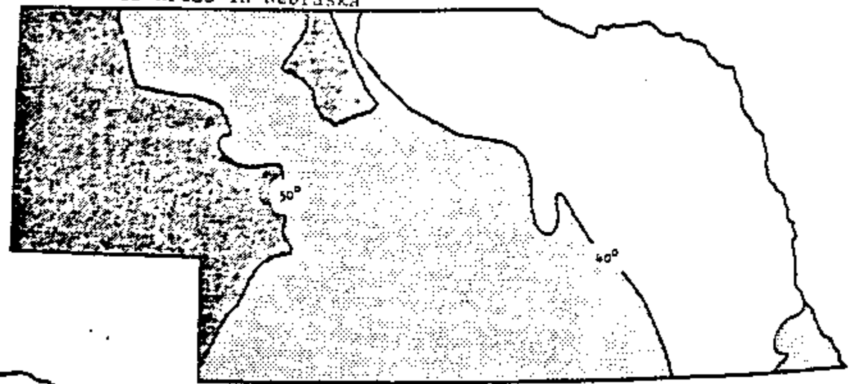
Chickens in Nebraska, 1977 (thousand head)



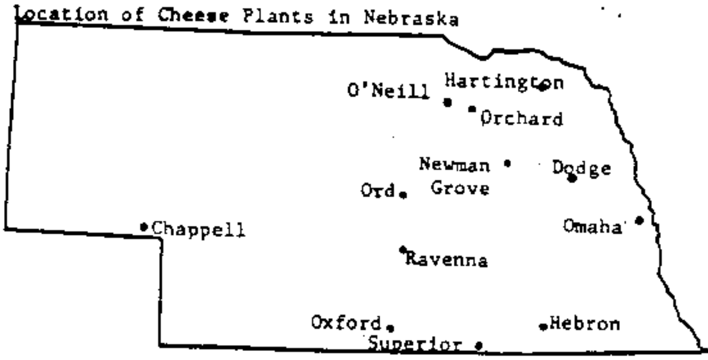
Source: "The Ethanol Distilling Industry: An Industrial Opportunity in Nebraska," p. 15.

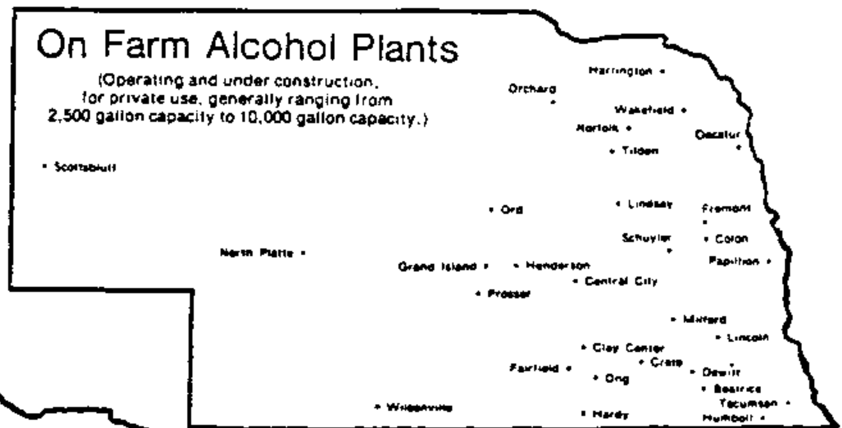
Review Locations of Geotherma_ Resources, Cheese Plants, and Alcohol Plants in Nebraska

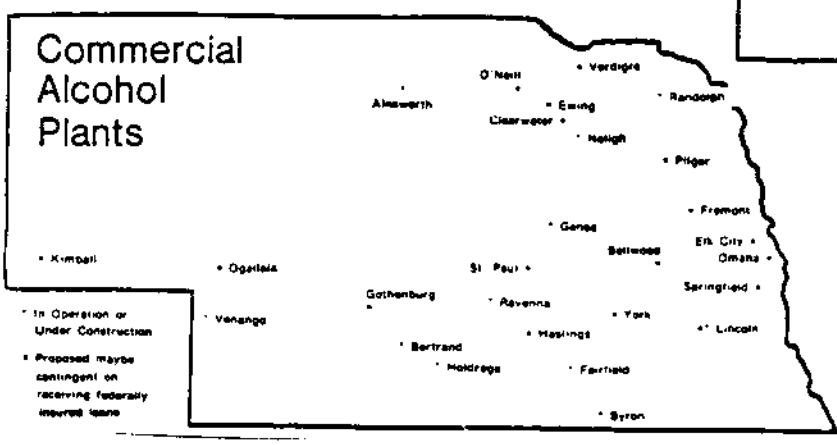
Geothermal Areas in Nebraska



Location of Cheese Plants in Nebraska







Review Crop Production Chart and Conversion/ Potential Alcohol Yield Chart

5 Year Crop Production in Nebraska and the United States

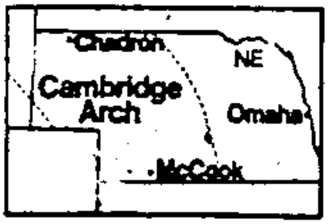
CROP	NE 1976	NE 1977	NE 1978	NE 1979	NE 1980	US 1976	US 1977	US 1978	US 1979	US 1980	UNITS
Corn	518.5	648.5	762.8	822.3	822.3	603.5	6,266.4	6,425.5	7,086.7	7,764.8	Mil. Bu.
Soybeans	19.6	40.7	42.5	54.7	53.1	1,287.6	1,761.8	1,870.2	2,267.6	1,817.0	Mil. Bu.
All Wheat	94.4	103.3	81.6	86.7	112.1	2,142.4	2,036.3	1,797.5	2,141.7	2,370.0	Mil. Bu.
Grain Sorghum	119.7	147.0	137.3	144.6	121.8	719.8	793.0	847.8	814.3	588.0	Mil. Bu.
Dry Edible Beans	1.98	1.77	1.95	2.16	2.58	17.8	16.6	19.0	20.7	26.1	Mil. Cwt.
Sugar Beets	1.69	1.35	1.37	1.46	1.78	29.4	25.0	25.7	22.0	23.2	Mil. Ton
All Hay	6.0	7.5	7.5	7.6	7.1	120.0	131.3	142.2	145.9	131.0	Mil. Ton
Potatoes	1.6	1.8	2.1	1.8	2.2	357.8	354.2	365.2	347.6	——	Mil. Cwt.

Review Conversion and Potential Yield Chart for Nebraska -

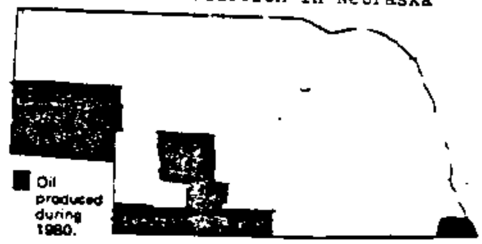
RAW MATERIAL	1980 SUPPLY	CONVERSION FACTORS			ALCOHOL YIELD
Corn	603.5 Million Bushels	2.6 Gal/Bu	93 Gal/Ton	237 Gal/Acre	1,569.1 Million Gallons
Wheat	112.1 Million Bushels	2.6 Gal/Bu	87 Gal/Ton	84 Gal/Acre	291.5 Million Gallons
Grain Sorghum	121.8 Million Bushels	2.8 Gal/Bu	100 Gal/Ton	146 Gal/Acre	341.0 Million Gallons
Potatoes	.11 Million Tons	1.4 Gal/Bu	29 Gal/Ton	------------	3.2 Million Gallons
Sugar Beets	1.8 Million Tons	8.14 Gal/Cwt	27 Gal/Ton	354 Gal/Acre	48.6 Million Gallons
Sweet Sorghum	--------------------	----------	----------	381 Gal/Acre	------------------
Fodder Beets	--------------------	----------	----------	900 Gal/Acre	------------------
Crop Residues	27.3 Million Tons	----------	35 Gal/Ton	------------	553.6 Million Gallons
Hay (dry)	7.0 Million Tons	----------	30 Gal/Ton	------------	20.0 Million Gallons
Wood	.4 Million Tons	----------	50 Gal/Ton	------------	18.4 Million Gallons
Whey Solids	.02 Million Tons	----------	86 Gal/Ton	------------	1.42 Million Gallons
Solid Urban Organic Wastes	.4 Million Tons	----------	30 Gal/Ton	------------	11.8 Million Gallons
			TOTAL POTENTIAL ALCOHOL YIELD		3,258.62 Million Gallons

Review of Traditional Fuels in Nebraska

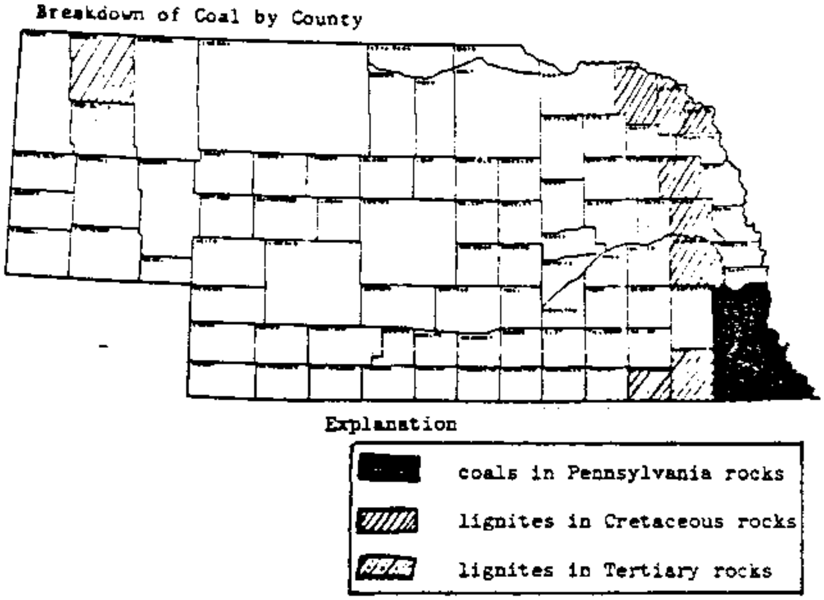
Natural Gas Potential in the Cambridge Arch



Regional Oil Production in Nebraska



Breakdown of Coal by County



Explanation

Footnotes

[1] The conversion figure used here is that 1 barrel of oil equals 42 U.S. gallons.

[2] Oil and Gas Journal, p. 29.

[3] EIA/1980 Annual Report to Congress, p. 74.

[4] Land available for Nebraska crop production is strictly defined by the Crop and Livestock Reporting Service as the Land In Farm Figure, which is based on annual sales of agricultural products of $1,000 or more, within a set place.

[5] Donald Hertzmark, p. 25.

[6] The ASCS Office (Price Support and Loan Division) projected that the 1981 grain production would be 1.1 billion bushels.

[7] This projection is from the ASCS office.

[8] "U.S. Grain-Reserve Program requires revision, addition," Lincoln Journal, 21 July 1981.

[9] This study entitled "Gasohol Marketing Channels Survey" is a Master's Thesis by Steven Pharr.

[10] DeBoer Brothers Production Plant, Smithfield, Nebraska; Archer Daniels Midland (ADM), Decatur, Illinois; Midwest Solvents, Atchison, Kansas.

[11] Alcohol would be the principle product produced, but four different by-products, which include distiller's grains, fuel oil, solubles and carbon dioxide, also result.

[12] Terry Klopfenstein, p. 46.

[13] Either ethanol or methanol produced only from biomass, not from fossil fuels, constitutes alcohol. Biomass is defined as any organic substance other than oil, or natural gas.

[14] This study prepared by The Development Planning and Research Associates of Manhattan, Kansas is under the title, "Feasibility of Converting a Sugar Beet Plant to Fuel Ethanol Production."

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