Energy Outlook

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Summary

It is difficult and dangerous to attempt a future energy forecast either for the United States or for Arizona. There are very large uncertainties and the energy area is very complex. This will cause a great deal of stress when established trends begin to interact with new views and directions. The problem is to react positively to the transition (which has already begun) from traditional sources of energy to those which are plentiful or renewable and which will stress conservation (or energy efficiency).

It is apparent that major shifts will be occurring which will make planning for those that use energy in their processes more difficult. It is also clear that there will be a significant stress on biomass fuels, of which only one is ethanol. Thus, we can assume that overall energy use will grow much less rapidly than earlier anticipated, there will be shifts to renewable resources, and there will be a great need for flexibility and option evaluation to avoid being caught unprepared.

Introduction

There are many differences of opinion that still prevail on the degree of energy problems that exist in the United States. Most of the confusion results from a combination of not having access to factual material or to receiving a significant amount of opinions of those that represent extreme viewpoints on the issue. Since the embargo of 1973-74, there have been a number of studies by industry, government, academic institutions, and private parties, resulting in much more information being available than in pre-embargo times. While there are still a number of diverse opinions, there is developing, a greater agreement on which alternatives are realistic.

The United States energy problem has been developing for a number of years and it will not be altered rapidly or easily. It is clear that projections of only a few years ago for future demands are continually being revised downward, and the type of individual energy sources that makes up total energy use is also changing, (toward renewable or plentiful sources).

Currently the United States depands heavily on traditional energy sources, with over 70% of the current total energy being derived from oil and natural gas. In the future, there will not only be a more efficient use of energy, but the U.S. will move away from the traditional sources into sustainable energy sources (either plentiful or renewable). This transition will probably take 20 to 30 years and will require the re-evaluation of some long-held traditional concepts and some informed public participation with many policies and option debates.

Selected Energy Facts

Prior to 1973 there was very little information available on actual energy use and production. Since that time, however, there has been a great deal of information made available and it is getting more accurate as it is evaluated and discussed by a variety of people from various interests.

The term used to compare the energy value between various energy sources is the BTU (British Thermal Unit). One BTU is approximately the amount of energy in burning a wooden match, and there are about 22 million BTU in a ton of coal, 5.5 million BTU in a barrel of oil, and 3,400 BTU in a kilowatt hour of electricity. For convenience, a quadrillion BTU (1,000,000,000,000,000) is defined as a quad.

The domestic United States energy consumption by use is shown in Table 1 for the years 1973-1979. During 1979, residential and commercial use accounted for 38%, industrial use was 37%, and transportation 25%.

Table 1. Domestic U.S, Energy Consumption: Use (Quads)

Year	Resi/Comm	Industrial	Transportation	Total
1973	25.8	29.9	18.9	74.6
1974	25.8	28.6	18.4	72.8
1975	26.0	26.2	18.5	70.7
1976	27.3	27.8	19.4	74.5
1977	28.3	28.3	19.8	76.4
1978	29.0	28.6	20.6	78.2
1979	29.5	28.8	19.8	78.1

Source: Monthly Energy Review (1980)

Domestic U.S. Energy consumption by source is shown in Table 2 for the years 1973-1979 and an increase can be noted in recent years for coal with a decrease in natural gas; during 1979, coal provided 19% of the overall energy supply, natural gas 26%, petroleum 47%, hydroelectric 4%, and nuclear 4% (although nuclear provided 12% of all electricity).

Table 2. Domestice U.S. Energy Consumption: Source (Quads)

Year	Coal	Natural Gas	Petroleum	Hydro-Electric	Nuclear	Total
1973	13.3	22.5	34.8	3.0	0.9	74.6
1974	12.9	21.7	33.4	3.3	1.3	72.8
1975	12.8	19.9	32.7	3.2	1.9	70.7
1976	13.7	20.3	35.2	3.1	2.1	74.5
1977	14.0	19.9	37.2	2.5	2.7	76.4
1978	13.8	20.0	38.0	3.2	3.0	78.2
1979	15.1	19.9	37.0	3.2	2.8	78.1

Source: Monthly Energy Review (1980).

Arizona usage is different than national usage, in that we have less used by industry and more transportation use. In Table 3 for 1975, residential and commercial accounted for 41%, industrial use was 23%, and transporation 34%. Arizona energy use by source is shown on Table 4; for 1978, coal produced 12%, natural gas 27%, petroleum 50% and hydroelectric 11% (there is no current use of nuclear energy for Arizona).

Table 3. Arizona Total Energy Consumption by Type (Trillion BTU's)

Year	Residential	Commercial	Industrial	Transportation	Total
1960	47	32	79	104	261
1970	78	93	132	183	486
1973	112	141	156	226	636
1975	119	140	143	210	614

Source: Helmut Frank (1977,79)

Table 4. Arizona Total Energy Consumption by Source (Trillion BTU's)

Year	Coal	Natural Gas	Petroleum	Hydro-power	Total
1960		143	92	26	261
1970	23	203	193	67	486
1973	15	223	317	81	636
1975	86	161	290	78	614
1978	75	179	325	73	651

Source: Helmut Frank (1977,79)

Selected Energy Facts for Agriculture

Agricultural energy demand or use is divided among transporation, industry, residential, and commercial in approximately even amounts (3-5% of each), so that total agricultural use accounts for about 15% of all national use. This includes on-farm production (which is 3-5% of national use) as well as processing, transporation, cooling, and refrigeration (See Table 5).

Table 5. Percent of US Energy Used in the Food System (1975)

Component	Direct	Indirect	Capital	Trans-port*	Total
Production	1.0	1.1	0.4	0.4	2.9
Manufacture	1.8	2.5	0.1	0.4	4.8
Distribution					
Wholesale	0.5		---	---	0.5
Retail	0.8		---	---	0.8

Preparation					
Out-of-home	2.0	0.2	---	0.6	2.8
In-home	3.3	---	0.3	0.7	4.3
Trucks	---	---	0.4	---	0.4
Total	13.2		1.2	2.1*	15.5

*Some transportation uses are included in "indirect" and "capital" figures for various components.

Source: USDA (1977)

Energy use in agriculture operations varies by location, type of process, and what is defined as "agricultural operation". There are opportunites for both conservation efforts switches to renewal energy sources. There may be shifts within the agricultural system that influence energy use (home gardens, local production, use of waste heat from other industries).

In terms of the production (field operations) use of energy, the greatest use nationally is fertilizer manufacturer (Table 6) and in Arizona the greatest use is irrigation (Table 7).

Table 6. Agricultural Energy Use (National)

UNITED STATES

ENERGY AND AGRICULTURE, 1978 DATA BASE. SUMMARY BY OPERATION A/
(DATA IS IN PHYSICAL QUANTITIES INDICATED)

OPERATIONS-CROPS	GALS OF GASOLINE (1000) C/	GALS OF DIESEL (1000) C/	GALS OF FUEL OIL (1000)	GALS OF LP GAS (1000)	CU FT OF NAT GAS (MILLION)	TONS OF COAL	KWH'S OF ELECT (MILLION)	INVESTED BTU'S (BILLION) B/	BTU TOTAL (BILLION)
PREPLANT	45949	1212328	-	17214	-	-	-	-	175537
PLANT	31178	315600	-	2076	-	-	-	-	47870
CULTIVATE	20310	338682	-	5406	-	-	-	-	50031
HARVEST	523994	582510	-	88593	-	-	-	-	154755
FARM PICKUP	1018323	1057	-	22234	-	-	-	-	129559
FERTILIZER APPLIC.	24251	70084	-	2567	-	-	-	-	12996
PESTICIDE APPLIC.	25271	92764	-	9535	-	-	-	-	16937
FARM TRUCK	535485	5747	-	-	-	-	-	-	67732
FARM AUTO-CROPS	486159	-	-	-	-	-	-	-	60767
GRAIN HNDLNG(VEHS)	15253	-	-	-	-	-	-	-	1905
GRAIN HNDLNG(MACH)	-	-	-	-	-	-	34	-	114
CROP DRYING(ON-FM)	-	-	62102	629396	700	-	565	-	71364
IRRIGATION	73622	136894	-	242512	134222	-	19453	-	254766
FROST PROTECTION	38866	27634	218548	1458	-	-	200	-	39824
FERTILIZER	-	-	-	-	-	-	-	652532	652532
PESTICIDES	-	-	-	-	-	-	-	68130	68130
ELECTRICITY	-	-	-	-	-	-	1696	-	5783
MISCELLANEOUS	72633	37162	-	-	-	-	-	-	14232
TOTAL-CROPS	2911293	2820464	280651	1020990	134922	-	21948	720662	1824843

OPERATIONS-LIVESTOCK	GALS OF GASOLINE (1000) C/	GALS OF DIESEL (1000) C/	GALS OF FUEL OIL (1000)	GALS OF LP GAS (1000)	CU FT OF NAT GAS (MILLION)	TONS OF COAL	KWH'S OF ELECT (MILLION)	INVESTED BTU'S (BILLION)	BTU TOTAL (BILLION)
LIGHTING	-	-	-	-	-	-	1734	N/A	5914
FEED HANDLING	120284	316904	-	29606	-	-	1110	N/A	65606
WASTE DISP.(VEHS)	91665	79759	-	12931	-	-	-	N/A	23756
WASTE DISP.(MACH)	-	-	679	6983	461	-	119	N/A	1639
WATER SUPPLY	-	13923	-	-	-	-	1537	N/A	7174
LIVESTOCK HANDLING	13763	1942	-	5719	-	-	-	N/A	2536
SPACE HEATING	-	1	-	54357	11	-	164	N/A	5761
VENTILATION	-	-	-	-	-	-	2020	N/A	6892
WATER HEATING	-	-	-	68220	-	-	946	N/A	9745
MILKING	-	-	-	-	-	-	794	N/A	2708
MILK COOLING	-	-	-	-	-	-	1301	N/A	4438
EGG HANDLING	-	-	-	-	-	-	31	N/A	106
BROODING	-	-	9539	215600	4669	36522	-	N/A	27512
FARM VEHICLES	214474	62225	-	8777	-	-	-	N/A	36278
FARM AUTO-LVSTK	68891	-	-	-	-	-	-	N/A	8611
OTHER	95283	12527	-	1659	-	-	205	N/A	14505
TOTAL-LIVESTOCK	604363	487283	10218	403845	5141	36522	9961	N/A	223179
TOTAL-AGRICULTURE	3515656	3307747	290869	1424835	140063	36522	31909	720662	2048022

(A) DATA INCLUDE ALL ENERGY USED DIRECTLY ON THE FARM FOR CROP AND LIVESTOCK PRODUCTION. NUMBERS MAY NOT ADD UP EXACTLY DUE TO ROUNDING. (B) INVESTED ENERGY INCLUDES THE ENERGY REQUIRED TO MANUFACTURE FERTILIZERS AND PESTICIDES (INCLUDING CARRIER SOLUTION). (C) GASOLINE & DIESEL USE REFLECT MACHINERY COMPLEMENTS AND CROP PRODUCTION TECHNOLOGIES IN 1978.

Source: USDA (1980)

Table 7. Agricultural Energy (Arizona)

ARIZONA

ENERGY AND AGRICULTURE, 1978 DATA BASE. SUMMARY BY OPERATION A/
(DATA IS IN PHYSICAL QUANTITIES INDICATED)

OPERATIONS-CROPS	GALS OF GASOLINE (1000) C/	GALS OF DIESEL (1000) C/	GALS OF FUEL OIL (1000)	GALS OF LP GAS (1000)	CU FT OF NAT GAS (MILLION)	TONS OF COAL	KWH'S OF ELECT (MILLION)	INVESTED BTU'S (BILLION) B/	BTU TOTAL (BILLION)
PREPLANT	22	14526	-	4	-	-	-	-	2018
PLANT	2	1867	-	-	-	-	-	-	259
CULTIVATE	8	5025	-	1	-	-	-	-	698
HARVEST	879	3451	-	121	-	-	-	-	600
FARM PICKUP	6000	2	-	-	-	-	-	-	750
FERTILIZER APPLIC.	5	1405	-	1	-	-	-	-	195
PESTICIDE APPLIC.	26	206	-	4	-	-	-	-	32
FARM TRUCK	1977	22	-	-	-	-	-	-	250
FARM AUTO-CROPS	2245	-	-	-	-	-	-	-	281
CROP DRYING(ON-FM)	-	-	-	21	-	-	-	-	2
IRRIGATION	-	-	-	-	14547	-	2098	-	22010
FROST PROTECTION	1338	1341	5963	1	-	-	7	-	1203
FERTILIZER	-	-	-	-	-	-	-	4802	4802
PESTICIDES	-	-	-	-	-	-	-	506	506
ELECTRICITY	-	-	-	-	-	-	6	-	21
MISCELLANEOUS	39	79	-	-	-	-	-	-	16
TOTAL-CROPS	12541	27924	5963	154	14547	-	2111	5307	33644

OPERATIONS-LIVESTOCK	GALS OF GASOLINE (1000) C/	GALS OF DIESEL (1000) C/	GALS OF FUEL OIL (1000)	GALS OF LP GAS (1000)	CU FT OF NAT GAS (MILLION)	TONS OF COAL	KWH'S OF ELECT (MILLION)	INVESTED BTU'S (BILLION)	BTU TOTAL (BILLION)
LIGHTING	-	-	-	-	-	-	22	N/A	73
FEED HANDLING	1799	1922	-	243	-	-	33	N/A	627
WASTE DISP.(VEHS)	910	227	-	128	-	-	-	N/A	158
WASTE DISP.(MACH)	-	-	-	15	-	-	-	N/A	2
WATER SUPPLY	-	-	-	-	-	-	3	N/A	11
LIVESTOCK HANDLING	277	2	-	37	-	-	-	N/A	38
SPACE HEATING	-	-	-	56	-	-	-	N/A	5
VENTILATION	-	-	-	-	-	-	5	N/A	16
WATER HEATING	-	-	-	813	-	-	2	N/A	83
MILKING	-	-	-	-	-	-	7	N/A	25
MILK COOLING	-	-	-	-	-	-	10	N/A	32
BROODING	-	-	-	27	-	5	-	N/A	3
FARM VEHICLES	3459	1	-	-	-	-	-	N/A	433
FARM AUTO-LVSTK	97	-	-	-	-	-	-	N/A	12
OTHER	459	13	-	-	-	-	2	N/A	66
TOTAL-LIVESTOCK	7001	2165	-	1320	-	5	82	N/A	1583
TOTAL-AGRICULTURE	19542	30089	5963	1474	14547	5	2193	5307	35227

(A) DATA INCLUDE ALL ENERGY USED DIRECTLY ON THE FARM FOR CROP AND LIVESTOCK PRODUCTION. NUMBERS MAY NOT ADD UP EXACTLY DUE TO ROUNDING. (B) INVESTED ENERGY INCLUDES THE ENERGY REQUIRED TO MANUFACTURE FERTILIZERS AND PESTICIDES (INCLUDING CARRIER SOLUTION). (C) GASOLINE & DIESEL USE REFLECT MACHINERY COMPLEMENTS AND CROP PRODUCTION TECHNOLOGIES IN 1978.

Source: USDA (1980)

Difficulties in Estimating Future Energy Supply and Demand

Energy is related to essentially every sector of socity. Key relationships are involved with international stability, economic strength, national security, environmental quality, and quality of life. As major policies change in each of these areas, there will be impacts on energy and its use.

Aside from having so many variables to contend with because of its relationship to overall society, several additional difficulties involved in estimating future supply and demand relate to: 1) specific quantities for reserves of traditional resources are generally known but change each year; 2) research on new types of energy sources may or may not work on a practical basis; 3) governmental incentives in pricing mechanisms using the taxation system have major impacts on society and therefore are not easily implemented; 4) international stability and national defense are increasingly related to energy; and 5) education and the ability to change will largely effect how rapidly conditions change.

The energy situation and its solution is not a simple matter of technology, but highly involved with public policy, national security, and fundamental resource availability. It is far more difficult to make future forecasts under these circumstances than most other aspects of society which require forecasting.

Further adding to the confusion about energy is a polarization and emphasis of the extreme views, quotations used out of context or without proper identification of assumptions, biased interpretations, and selective use of limited data.

Future Energy Outlook

Prior to the embargo of 1973-74, energy forecasting was largely done by extrapolation of past trends and thus it was relatively easy to match supply and demand. Because of the problems discussed above, however, it is not at all easy to make these types of forecasts today. In addition, as more is known about alternative energy sources and the economic desirability of conservation over additional production, energy demand estimates are continually being revised down.

There are no estimates of future energy needs and demands developed by Arizona. There are also no studies on risks and benefits of the variety of possible energy futures for Arizona. The questions concerning future Arizona energy use are difficult and in need of being asked and discussed. Because of its rapid growth, water, changing industrial mix, and potential for coal, solar, and geothermal sources, future options for the state may differ significantly from the nation.

Even though Arizona has not made detailed studies, others have. An example is the estimate of future electrical energy demand in Arizona. The U.S. General Accounting Office did a study of two scenarios: Scenario I is based on current utility projects (major reliance on oil, coal and nuclear); Scenario II considers efforts by the public, industry and government toward energy conservation and alternative renewable sources, (Table 8). They note that Scenario II (which is 29% less energy use than Scenario I in the year 2000), has demonstrated benefits in environment, equity, economy, and risk and will give a lower cost to the consumer with little change in lifestyle for the general public. This points up the difficult and great risks involved in forecasting future energy use. The differences between those planning for energy production and the rest of society will require broad discussion and agreement before any realistic future estimates can be made.

Table 8. Arizona Electrical Energy Used by Final Consumers
(in billion kWh)

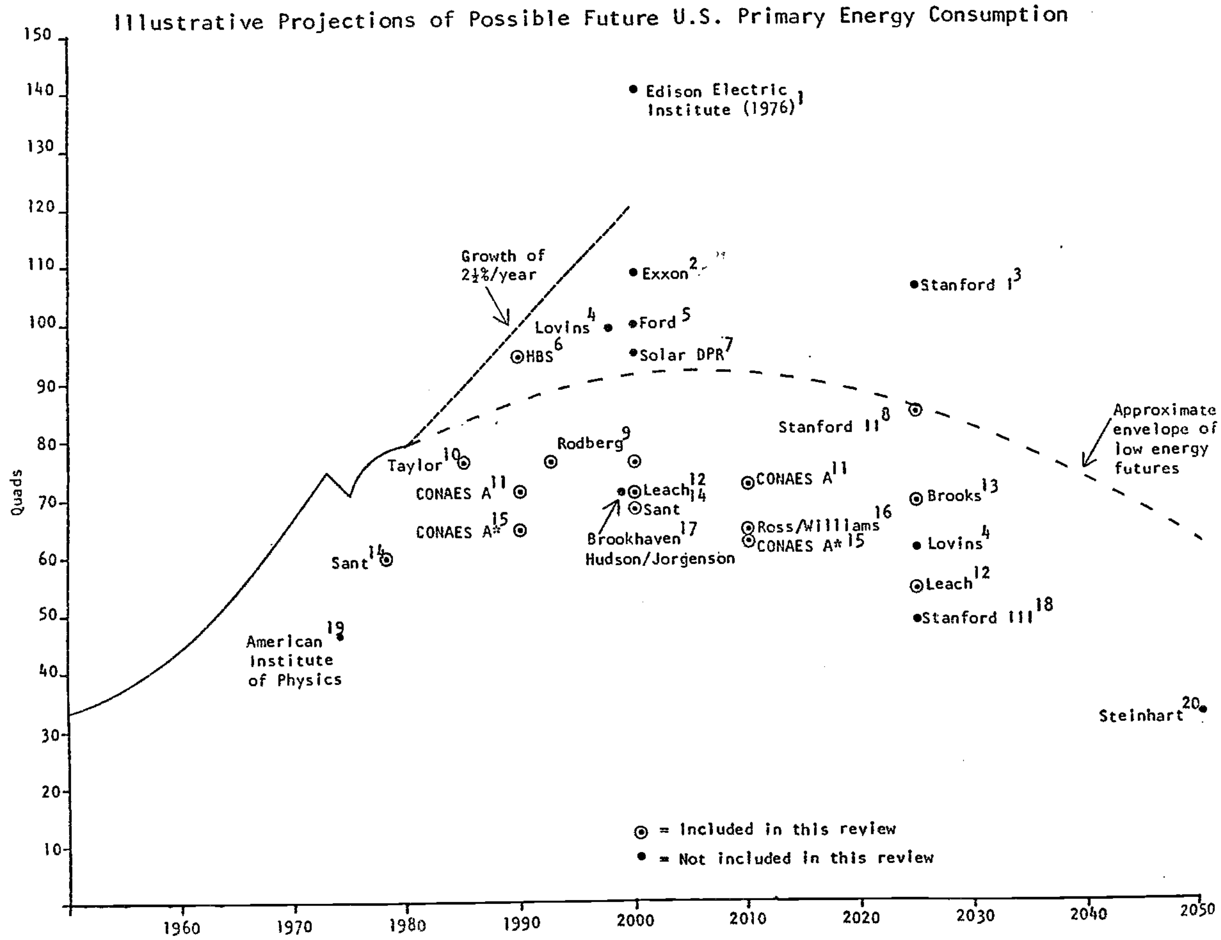
	1975	1980	2000
Scenario I:			
Residential	7.3	14.3	24.8
Commercial	5.8	12.5	25.1
Industrial	5.7	10.2	13.6
Agricultural	2.3	2.7	3.3
Other	.6	.8	1.2
Total	21.7	40.5	68.0
Scenario II:			
Residential	7.3	12.0	18.5
Commercial	5.8	7.8	12.4
Industrial	5.7	9.9	13.0
Agricultural	2.3	2.4	3.0
Other	.6	.7	1.1
	21.7	32.8	48.0

Source: U.S. General Accounting Office.

This same scenario approach has been used nationally. The United States currently uses about 78 quads of energy, which was expected to reach nearly 200 quads by the year 2000 in estimates made before the embargo (1973). More recently, the lower range of estimates has been shown to be less than 100 quadrillion BTU for the same time period (year 2000). An example of 17 estimates of lower energy futures is shown in Figure 1. As forecasts continue to be made, the trend has generally been for lower anticipated demands than developed by previous studies. These reduced energy needs will come about by more efficient processes, switching to renewable resources, and still cause relatively minor changes in life style.

For example, there are already in place standards for new equipment efficiency for such common appliances as refrigerators, air conditioning units, furnaces, and hot water heaters. There are energy efficiency goals established for new cars, currently ending in 1985 with a goal of 27.5 miles per gallon for the fleet wide average. There are building standards under disucssion where a certain building use would have to achieve a specific energy use per square foot to qualify for loans and permitting. There is increasing use of passive solar energy design, such that energy use is minimized both in summer and winter. However, conservation is not the whole answer, and there will be shifts to the renewable natural resources as well as continuing new research and development on new sources and continuing our existing traditional sources for sometime into the future. Coal is the most abundant traditional source and a switch has already begun to get coal away from natural gas and oil. Because of the small current usage, solar energy is expected to grow rapidly, and some of the newer sources, such as geothermal or ocean thermal gradient energy has been shown to compete effectively with traditional sources for some applications. Increasingly, it is becoming clear to many that major shifts are under way in the way the world and the United States use energy. The shifts will not result from one breakthrough in a major new source or from conservation, but will be a mixture of both production and conservation techniques. The problem lies in developing a broad understanding as to reasons why change is needed, so we can anticipate new events rather than react to them.

Figure 1



From US DOE (1980): numbers on chart refer to those in reference

Conclusion

It is too early to evaluate the energy mix that will be available in the next 20 years. In the absence of national policies, the decision on future use of nuclear energy and solar energy (including biomass) has not yet been made in terms of its potential contribution. The answer will become more clear as more discussion and debate occurs in the next several years.

There are many uncertainties, but choices will have to be made soon (in the next few years). No longer can energy decisions be made by those only in the energy industries and certain government agencies. Instead, the issues will be widely discussed with public involvement (and confusion). While the public debate continues, all energy options should be kept open. However, when society makes its choice, those options which are chosen will have to be pursued rigorously.

Selected References

1. Caldwell, Roger L. 1980. United States Transition Years (Book Review). ACCES-Energy, June, 1980. Council for Environmental Studies, University of Arizona, Tucson, Az. 85721, 4 p.

2. Council for Agricultural Science and Technology. 1977. Energy Use in Agriculture: Now and for the Future, Report 68. Iowa State University, Ames, IA 50011, 28p.

3. Frank, Helmut, J. 1977 (with 1979 update). Arizona Energy Inventory: 1977. University of Arizona for Arizona Office of Economic Planning and Development. 100 p.

4. Hale, Ellen (Editor). 1976. Arizona Energy: A Framework for Decision. University of Arizona Press.

5. National Academy of Sciences. 1979. Energy in Transition: 1985-2010. W.H. Freeman and Co., San Francisco, Ca. 677 p.

6. Sawhill, John C. (Editor). 1979. Energy Conservation and Public Policy. Prentice Hall, Englewood Cliffs, N.J. 259 p.

7. Strobaugh, Robert and Daniel Yergin. 1979. Energy Future. Random House, New York, New York. 353 p.

8. U.S. Congress, General Accounting Office. 1979. Electrical Energy Development in the Pacific Southwest. EMD 79-73, 196 p.

9. U.S. Department of Agriculture. 1977. Energy Use in the Food System. Washington, D.C.

10. U.S. Department of Agriculture. 1980. Energy and U.S. Agriculture: 1974 and 1978. Economics, Statistics and Cooperatives Service Statistical Bulletin 632, Washington, D.C. 114 p.

11. U.S. Department of Energy, 1980. Monthly Energy Review, Washington, D.C.

12. U.S. Department of Energy. 1980. Low Energy Futures for the United States. DOE/PE-0020, Washington, D.C. 127 p.

Some Economic Aspects of Ethanol Production

by

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As we enter the decade of the eighties, the outlook for liquid fuels is very uncertain. World oil production is leveling off and most energy analysts agree that output may not increase much more, if at all. Coupled with this unfavorable production prospect is a growing uncertainty of supply. Since the end of World War II, the potential for disruption in oil supplies has never been so great. The unsettled political situation in the Middle East and the Russian invasion of Afghanistan only tends to heighten the feeling of uncertainty with respect to supply availability and crude oil prices. A continually climbing world oil price, with no apparent limit in sight, signals a fundamental change in the outlook for liquid fuels in many countries of the world.

Against this backdrop of events, many countries are turning to ethanol (anhydrous ethyl alcohol) distilled from farm commodities as a source of fuel for automobiles. An alcohol fuel industry has several attractions to policy makers in the United States:

1. Automobile engines can readily burn a gasoline/alcohol mixture containing 10 percent alcohol without any adjustment or significant loss in engine fuel efficiency or performance.
2. Commercial production of alcohol for industrial purposes is already a well established industry and the technology for converting plant materials into alcohol is widely available.
3. Limited supplies of crude oil can be extended by substituting 10 percent alcohol for gasoline in the gasohol mix.
4. The demand for alcohol would open new markets for surplus grain supplies and other plant materials. Idle cropland could be brought into production to produce raw materials for this developing market. For the first time, American farmers would consider producing crops for "fuel" rather than for "food".
5. New productive capacity can come on stream within 6-18 months from the start of construction.

In January 1980, the White House announced major new goals for both 1981 and the mid-eighties. The aim is to produce 500 million gallons of ethanol for fuel in 1981, a figure at least six times greater than the 1979 output. Distilling 500 million gallons of ethanol would require 225 million bushels of corn (assuming 2.22 gallons of ethanol per bushel of corn), the output from 2.25 million acres at current U.S. yields.

Secretary of Agriculture, Bob Bergland, believes that the President's 1981 goal is reachable because a combination of events critically influencing ethanol plant construction decisions that make investment sufficiently profitable to offset anticipated risks. 2/ These factors include:

1/ Respectively, Extension Economist, Cooperative Extension Service; Project Coordinator, Arizona Geothermal Team; and Chemical Engineer (all of the University of Arizona, Tucson, Arizona).

2/ Statement by Bob Bergland before the U.S. National Alcohol Fuels Commission, June 19, 1980.