Analysis of Energy Supply and Usage in the Iowa Economy

Executive Summary

This report addresses the needs of state policymakers to understand the implications to the state's economy from current levels of energy supply imports. Historical energy consumption patterns for the state and the role of energy in the performance of the Iowa economy are reviewed using current data. Economic modeling techniques are then used to analyze the linkages of these energy sectors, forward and backwards, with the rest of the economy. Information on the importance of energy to various economic activities and the share of energy expenditure that goes to in-state vs. out-of-state sources, including the energy distribution functions, is also provided. The objective of this report is to review the information on the quantities of energy consumed and dollars spent in Iowa and evaluate the share of these energy dollars that are leaving the state.

While the majority of the primary, or raw energy sources, such as coal and crude oil, used to generate consumer-ready energy come from outside Iowa, there is considerable economic activity involved in getting that energy processed, converted and distributed to final consumers and businesses. Energy distribution is a service industry as well as a goods-producing industry. Much of the value of gasoline at the pump and electricity or natural gas at the meter is provided by the process of getting those resources from a hole in the ground to the final consumer in a form that can be efficiently utilized. Much of this value is added within the Iowa economy.

Spending for petroleum product imports represent the largest dollar expenditure for energy in Iowa. In terms of percentage share of inputs, natural gas import expenditures represent the largest share of energy dollar being spent for imported energy. According to IMPLAN estimates, 52.4 percent of the total expenditures for natural gas leak out of the state. The percent leakage for industrial processing and distribution of petroleum is higher because of the lack of any refining capacity in Iowa. If we include the margins for retailing and wholesaling, however, 41.6 percent of the total expenditure for petroleum products leaves the state. The leakage share is smallest for electricity because most of the generation occurs within Iowa, and the distribution functions all are within state. Our estimates indicate only 17.8 percent of the total electricity expenditures leak out of Iowa.

Analysis of Energy Supply and Usage in the Iowa Economy

December 19, 2005

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This report was prepared with a grant from the U.S. Department of Energy (DOE). However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of the DOE.

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Modern economies are very energy dependent across both the production and the consumption sectors, including residential, industrial, commercial, and transportation activities. As the Iowa economy moves into the future, growing service and commercial sectors will continue to diversify our traditional reliance upon agriculture and manufacturing activities. This can be expected to change existing patterns of energy usage.

Because Iowa is without primary energy sources such as coal, oil, or natural gas, Iowa policy makers and the public need to be aware of implications to the state's economy from importing energy supplies, particularly in the face of economic transitions. This report addresses these needs by reviewing the historical energy consumption patterns for the state and the role of energy in the performance of the Iowa economy. Using current data, economic modeling techniques are used to analyze the linkages of these energy sectors, forward and backwards, with the rest of the economy. Information on the importance of energy to various economic activities and the share of energy expenditure that goes to in-state vs. out of state sources, including the energy distribution functions, is also provided. The objective of this report is to review the information on the quantities of energy consumed and dollars spent in Iowa and evaluate the share of these energy dollars that are leaving the state.

Energy Consumption

Energy consumption by source of energy includes primary fuels that are consumed directly, such as natural gas, and energy that needs to be converted (coal into electricity) or processed (oil into gasoline and petroleum products). Table 1 details the composition of that energy consumption for Iowa according to the fuel sources from 1970 to 2001[1]. During this period, Iowa's consumption (BTU) of energy by source increased 16 percent for petroleum, 240 percent for coal, and 188 percent for electricity. Consumption of natural gas fell by 36 percent. During the period, total Iowa energy consumption from all sources increased by 35 percent.

[1] The most recent comprehensive listing of energy consumed in Iowa is available from the U.S. Department of Energy's Energy Information Administration and is based on 2001 data. Updates are available for several individual energy components.

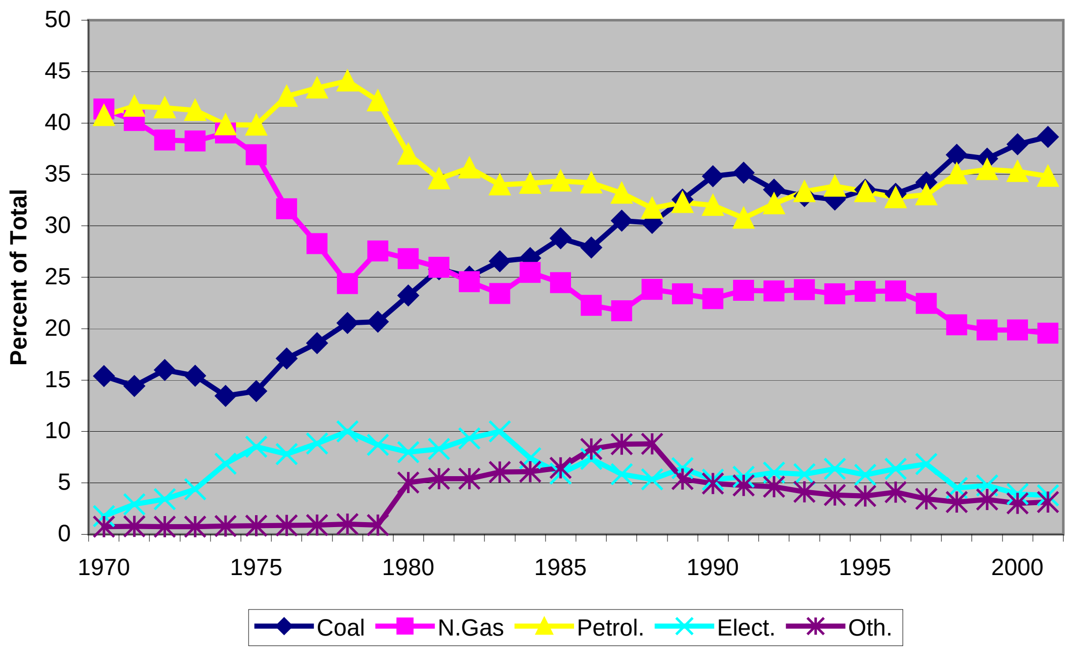
Table 1. Iowa Energy Consumption by Source, Volume, and Energy Content, 1970-2001

Year	Coal		Natural Gas		Petroleum										Electric Power				Oth.	Net Interstate Flow of Electricity		Grand Total
					Dist. Fuel		LP Gas		Motor Fuel		Oth. Petrol.		Tot. Petrol.		Nuclear		Hydro					
	1,000 Short Tons	BTU (T)	Bil. Cu. Ft.	BTU (T)	1,000 Bbls.	BTU (T)	1,000 Bbls.	BTU (T)	1,000 Bbls.	BTU (T)	1,000 Bbls.	BTU (T)	1,000 Bbls.	BTU (T)	Mill. kWh	BTU (T)	Mill. kWh	BTU (T)	BTU (T)	Mill. kWh	BTU (T)	BTU (T)
1970	6,166	130.9	349	351.8	13,677	79.7	11,038	41.7	35,701	187.5	6,113	38	66,528	346.4	0	0	935	9.8	6.3	1,572	5.4	850.6
1971	5,896	124.7	345	347.7	14,257	83	11,139	42	37,325	196.1	6,306	39	69,026	359.9	0	0	913	9.6	6.6	4,609	15.7	864.2
1972	6,945	144.9	345	347.6	14,941	87	12,506	47	38,404	201.7	6,564	40	72,416	376	0	0	993	10.3	6.9	6,106	20.8	906.5
1973	7,026	148.7	365	369	15,531	90.5	12,692	47.5	42,104	221.2	6,341	39	76,667	397.9	0	0	906	9.4	7.3	9,628	32.8	965.1
1974	6,173	128.2	368	371.6	14,825	86.4	13,369	49.9	38,847	204.1	6,411	39	73,453	379.4	1,330	14.8	891	9.3	7.7	12,114	41.3	952.3
1975	6,407	131.6	346	348.6	14,553	84.8	13,645	50.7	39,042	205.1	5,783	35	73,024	375.8	2,291	25.2	879	9.1	7.9	13,583	46.3	944.5
1976	8,311	169.5	311	313.9	15,088	87.9	18,586	69	40,738	214	8,604	51	83,016	422.3	2,479	27.4	645	6.7	8.5	12,673	43.2	991.5
1977	9,175	185.1	280	281.4	15,977	93.1	17,854	65.6	41,237	216.6	9,518	57	84,587	432.3	2,888	31.1	780	8.1	9	14,231	48.6	995.5
1978	10,110	201.3	238	238.8	16,915	98.5	15,698	57.6	40,927	215	10,142	61	83,681	431.8	1,209	13.2	930	9.6	9.6	22,045	75.2	979.6
1979	11,352	219.4	292	292.2	20,711	120.6	14,686	54	38,501	202.2	11,823	70	85,722	447.2	2,889	31.4	898	9.3	9.7	15,158	51.7	1,061.00
1980	12,340	234.4	270	270.4	15,930	92.8	11,167	41	35,394	185.9	9,232	53	71,721	373.1	2,563	28	946	9.8	50.8	12,532	42.8	1,009.30
1981	13,483	252.1	253	254	14,513	84.5	9,891	36	34,274	180	6,387	38	65,066	338.4	2,204	24.3	982	10.3	52.9	13,638	46.5	978.6
1982	13,033	243.9	237	239	16,235	94.6	11,953	43.2	33,030	173.5	5,919	36	67,137	346.6	2,269	25.1	918	9.6	52.7	16,425	56	972.9
1983	13,540	253.7	221	223.6	14,099	82.1	12,026	43.5	32,386	170.1	4,875	29	63,387	324.9	2,309	25.2	920	9.7	57.8	17,798	60.7	955.6
1984	13,624	251.5	235	238.4	15,716	91.5	7,336	26.4	32,223	169.3	5,452	32	60,727	319.6	2,700	29.3	918	9.6	57.1	8,945	30.5	936
1985	14,342	268.8	226	228.4	15,823	92.2	8,507	30.7	31,465	165.3	5,462	33	61,258	320.8	1,927	20.5	989	10.3	60.4	7,138	24.4	933.6
1986	13,862	262.1	207	209	16,214	94.4	8,774	31.9	31,355	164.7	4,919	30	61,261	321.1	2,993	31.7	953	10	78.1	8,009	27.3	939.3
1987	15,191	287.3	203	204.7	16,531	96.3	6,098	22.3	31,687	166.5	4,527	28	58,844	312.4	2,523	26.3	971	10.1	82.5	5,463	18.6	942.1
1988	16,114	306.1	239	240.8	16,333	95.1	6,612	24.1	32,509	170.8	4,996	31	60,450	320.6	3,163	33.5	699	7.2	89	3,969	13.5	1,010.80
1989	17,126	317.7	226	228.2	15,600	90.9	7,174	26.4	32,574	171.1	4,381	27	59,729	314.9	3,139	33.2	672	7	52.4	6,628	22.6	976
1990	18,080	335	219	220.4	15,784	91.9	6,355	23	31,684	166.4	4,400	27	58,223	307.9	3,012	31.9	875	9.1	47.6	3,030	10.3	962.2
1991	18,905	349.3	234	235.8	14,513	84.5	7,255	26.2	32,471	170.6	4,014	24	58,254	305.6	4,147	43.5	901	9.4	47.2	777	2.7	993.4
1992	18,143	329.2	232	232.5	16,066	93.6	8,978	32.5	31,713	166.6	3,858	23	60,615	315.9	3,405	35.7	1,000	10.3	45.5	3,808	13	982.2
1993	19,328	344.1	248	248.8	16,699	97.3	15,651	56.4	32,703	171.8	3,838	23	68,892	348.6	3,235	34	747	7.7	43.2	5,727	19.5	1,046.00
1994	19,460	348.9	248	250.5	17,293	100.7	15,663	56.9	33,887	177.2	4,589	28	71,432	362.9	4,107	42.9	1,071	11	40.9	4,185	14.3	1,071.40
1995	20,728	372.3	261	262.5	17,748	103.4	16,989	61.5	34,418	179.5	4,273	26	73,427	370.3	3,730	39.2	1,003	10.3	41.6	4,265	14.6	1,110.80
1996	21,301	383.7	272	274	19,793	115.3	11,344	41	35,909	187.3	6,045	36	73,092	379.4	3,924	41.2	935	9.7	47.5	6,672	22.8	1,158.30
1997	21,798	391.7	254	256.8	19,652	114.5	10,296	37.2	35,577	185.5	6,790	41	72,316	377.8	4,149	43.5	805	8.2	39.5	7,827	26.7	1,144.20
1998	23,275	424.9	232	234.6	20,058	116.8	14,882	53.8	36,973	192.7	6,857	41	78,771	403.9	3,768	39.5	913	9.3	36.1	956	3.3	1,151.60
1999	23,590	432	231	235.1	19,588	114.1	18,746	67.8	36,993	192.8	7,480	45	82,807	419.4	3,640	38	946	9.7	39.9	2,461	8.4	1,182.40
2000	24,480	445.9	233	233.7	19,261	112.2	19,621	70.8	36,753	191.5	6,782	40	82,417	414.8	4,453	46.4	904	9.2	35.5	-2,832	-9.7	1,176.00
2001	24,398	444.9	224	225.2	20,101	117.1	16,127	58.3	36,768	191.6	5,720	34	78,716	400.9	3,853	40.3	845	8.6	36	-1,519	-5.2	1,150.70

Data from U.S. Department of Energy, Energy Information Administration

Figure 1 shows consumption by source (calculated from BTUs consumed) as a percent of total Iowa energy consumption from 1970 through 2001. Figure 1 clearly shows that petroleum and natural gas, as shares of total consumption, fell substantially during the late 1970s. Coal's share as an Iowa energy source has steadily increased throughout the period.

Figure 1. Iowa Energy Consumption (BTU) Shares by Source, 1970-2001



While much of the electricity used in Iowa is generated in state, many of the inputs and most of the primary fuel for generating this electricity, predominantly coal, originate from out of state. A small amount of hydropower-generated electricity and a growing volume of wind- generated electricity are produced within Iowa. All of the natural gas and petroleum supplies are produced outside of Iowa. The economic activities surrounding natural gas and petroleum-product sales relate mainly to distribution, retailing and taxes. As a result, a large share of the energy dollar expenditures by Iowa consumers, businesses and public sector agencies goes out of state to import basic energy resources. At the point where these funds move out of state, they no longer circulate through the Iowa economy, supporting additional economic activity through business and personal transactions. A later section of this report will estimate the value of the share of these energy dollars that are leaving the state through the purchase of inputs from out of state.

Another way to present data on energy consumption in Iowa is to look at primary energy consumption by sector. Data on energy consumption by sector includes mixes of all primary energy sources used in residential, commercial, industrial, and transportation sectors. Information on consumption in Iowa by sector is presented in Table 2.[2]

[2] Table 2 also shows usage of primary energy for the electrical generation sector. The use of primary energy in electrical generation has risen to two-and-a-half times what it was in 1970. The increasing use of primary energy in electrical generation reflects the convenience and flexibility of electricity as a power source for fixed installations (residences, factories, offices, and commercial establishments). This trend

Table 2. Total Iowa Energy Consumption and Expenditure by Sector, 1970-2001

	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		TRANSPORTATION		ELECTRIC POWER	
Year	$Millions	Trillion BTU	$Millions	Trillion BTU	$Millions	Trillion BTU	$Millions	Trillion BTU	$Millions	Trillion BTU
1970	333.4	217.4	151	113.7	276.1	309.2	499.2	210.2	50.4	175.2
1971	344.8	214.9	164.6	117.7	276	301.6	556.2	230	59	175.5
1972	389	228.2	185.2	123.9	303.6	315.5	592.3	238.9	70	185.6
1973	446.6	225.5	202.1	128.4	365.9	354.8	677.2	256.5	80.5	187.1
1974	479.5	224.9	230.7	130.6	486.2	350	876.9	246.9	100.6	186.2
1975	554.2	231.6	287.7	139.9	537.4	324.6	984.9	248.5	132.5	187
1976	610.7	228.8	338.3	141.8	683.6	363.6	1,106.80	257.4	162.4	201.3
1977	698.3	229.4	393.4	141.6	797.8	363.4	1,219.30	261.1	194.8	210.4
1978	758.3	233.1	424.1	136.2	845.6	350.3	1,279.80	260	232.1	204.8
1979	944.3	252	534.8	150.9	1,113.70	399	1,675.70	259.1	258	230.9
1980	1,026.00	243.3	506.2	125.8	1,366.50	402.2	2,103.80	238	313.1	246.6
1981	1,122.00	229.3	658.8	136.3	1,472.30	387.8	2,255.70	225.1	352.6	255.1
1982	1,311.80	244.6	754.9	142.7	1,419.80	358.3	2,189.10	227.3	356	247.4
1983	1,403.10	241.7	832.1	144.9	1,364.80	343.6	1,964.30	225.3	387.6	257.6
1984	1,324.20	223.1	796.5	135.1	1,416.40	353	1,912.00	224.9	367.3	257.9
1985	1,309.80	223.6	779.5	134.2	1,450.10	356.1	1,871.20	219.6	389.3	265.1
1986	1,272.70	219.4	733.2	129.4	1,281.60	375.1	1,484.10	215.4	334.7	265.6
1987	1,193.70	205.1	655.1	126.1	1,149.80	386	1,584.00	224.9	325.6	279
1988	1,278.70	224.5	696.6	138.5	1,210.40	415.6	1,610.70	232.1	353.8	304
1989	1,302.60	227.5	686	140	1,087.50	375	1,830.30	233.5	348.4	303.3
1990	1,291.60	214.2	690.4	140.7	1,152.90	374.5	2,061.00	232.7	346.5	322
1991	1,362.00	230.5	755.7	150.3	1,196.30	387.9	1,948.50	224.6	358.1	342.9
1992	1,335.40	215.1	754.7	143.8	1,387.10	400.8	1,856.40	222.4	335	324.5
1993	1,470.80	233.8	827.7	156.1	1,622.30	423.2	1,886.70	232.9	333.9	339.4
1994	1,448.40	227.6	798.2	151.9	1,637.50	443.8	2,043.60	248.2	334.4	352.1
1995	1,507.10	238.8	813	157.7	1,631.10	457	2,100.80	257.3	354.4	368
1996	1,636.30	249.1	873.5	164.4	1,664.10	471.9	2,442.40	272.9	339.7	368.3
1997	1,649.90	240.8	921	168.5	1,707.70	468.4	2,361.40	266.7	348.8	376.4
1998	1,533.90	226.4	884.4	164.2	1,707.10	485.1	2,090.40	276	363.5	415.5
1999	1,583.30	233.9	910.4	172.6	1,872.80	501.4	2,264.70	274.5	342.5	417.6
2000	1,807.20	236.3	1,052.80	173	2,440.90	495.5	2,988.10	271.3	367.4	445.8
2001	1,846.60	229.3	1,107.60	179	2,386.50	472.3	2,819.80	270.1	368.7	440.2

Data from U.S. Department of Energy, Energy Information Administration

Weather patterns can have a significant impact on levels of residential energy consumption and economic patterns affect energy consumption in industrial and commercial sectors. Global geopolitical issues can also significantly affect energy prices and consumption as evidenced by the sharp energy expenditure increases experienced during the energy crises of 1973 and 1979.

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will undoubtedly continue. While Table 2 shows the rate at which energy usage is moving towards electricity, this cannot be viewed or displayed as a separate sector, as electrical usage is also counted as a component of commercial, industrial, transportation, and residential utilization.

Figure 2 shows Iowa energy consumption (BTU) shares as percents of total Iowa consumption. The industrial and commercial shares increased over the period. Transportation's share rose and then fell over the period, without much change overall. The residential share has fallen over time.

Figure 2. Iowa Energy Consumption (BTU) Shares by Sector, 1970-2001

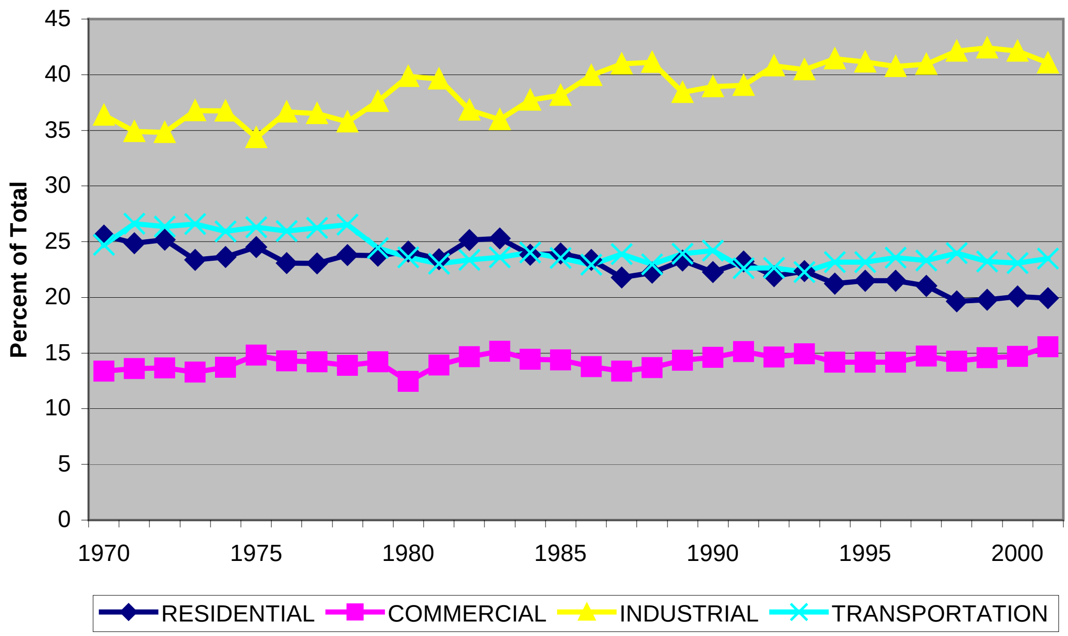
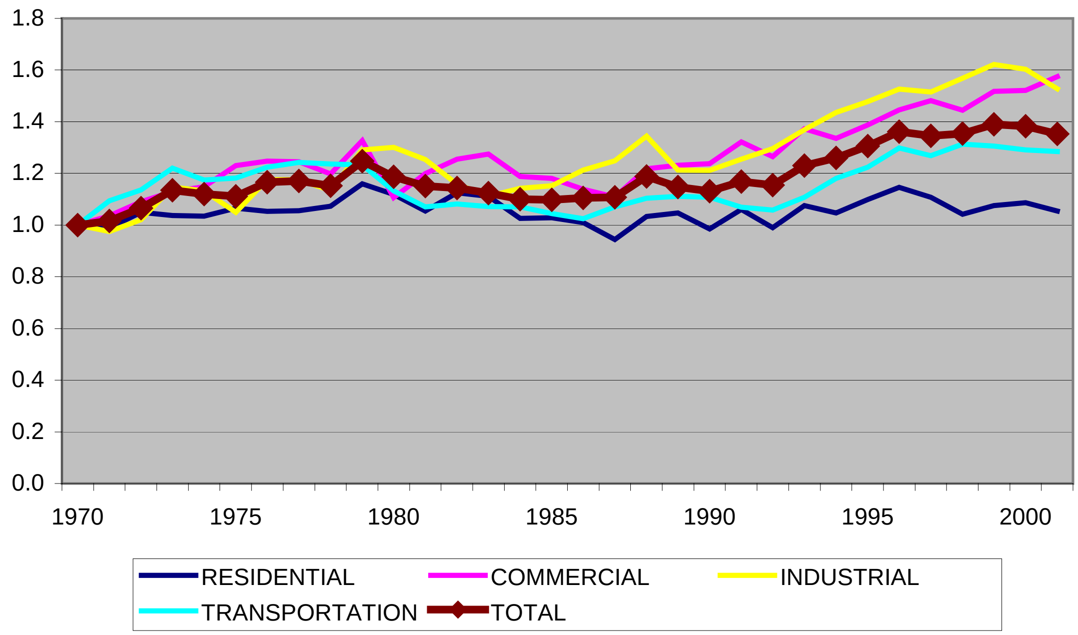


Figure 3 shows relative changes in total usage of primary energy by sector. Over all, Iowa's primary energy utilization has increased by over 35 percent from 1970 to 2001. Residential utilization of primary energy has remained fairly stable. The commercial and industrial sectors' usage levels have risen by a little over 50 percent. Transportation sector utilization increased by 28 percent. Residential use increased by only 5 percent from 1970 to 2001.

Figure 3. Relative Change in Sector Energy Usage, 1970-2001



Energy and the Iowa Economy

Historically, energy consumption has been closely related to the performance of the economy. The aggregate performance of the Iowa economy as measured by Gross State Product (GSP) is presented in Table 3. In addition to simple measures of Iowa GSP and the sum total GSPs for the U.S., Table 3 provides comparable population numbers, calculations of GSP per capita, and trends in the consumer and producer price indices (CPI and PPI).

Table 3. Comparisons of Gross State Product for Iowa and the Total United States

	Gross State (Area) Product				Population				Gross Product Per Capita				Price Indices			
	Iowa		United States		Iowa		United States		Iowa		United States		Consumer		Producer	
Year	$millions	Index	$millions	Index	People	Index	People	Index	Dollars	Index	Dollars	Index	Index	Chg.	Index	Chg.
1977	26,385	1.00	1,986,138	1.00	2,914,308	1.00	219,760,875	1.00	9,054	1.00	9,038	1.00	60.6	1.00	64.9	1.00
1978	30,121	1.14	2,243,638	1.13	2,919,008	1.00	222,098,244	1.01	10,319	1.14	10,102	1.12	65.2	1.08	69.9	1.08
1979	32,765	1.24	2,491,428	1.25	2,916,803	1.00	224,568,579	1.02	11,233	1.24	11,094	1.23	72.6	1.20	78.7	1.21
1980	34,032	1.29	2,719,134	1.37	2,914,018	1.00	227,224,719	1.03	11,679	1.29	11,967	1.32	82.4	1.36	89.8	1.38
1981	37,866	1.44	3,064,552	1.54	2,907,985	1.00	229,465,744	1.04	13,021	1.44	13,355	1.48	90.9	1.50	98	1.51
1982	36,910	1.40	3,217,617	1.62	2,888,190	0.99	231,664,432	1.05	12,780	1.41	13,889	1.54	96.5	1.59	100	1.54
1983	36,957	1.40	3,451,340	1.74	2,870,547	0.98	233,792,014	1.06	12,875	1.42	14,762	1.63	99.6	1.64	101.3	1.56
1984	41,031	1.56	3,872,847	1.95	2,858,615	0.98	235,824,907	1.07	14,353	1.59	16,423	1.82	103.9	1.71	103.7	1.60
1985	42,381	1.61	4,155,029	2.09	2,829,684	0.97	237,923,734	1.08	14,977	1.65	17,464	1.93	107.6	1.78	103.2	1.59
1986	43,111	1.63	4,364,279	2.20	2,791,969	0.96	240,132,831	1.09	15,441	1.71	18,174	2.01	109.6	1.81	100.2	1.54
1987	45,055	1.71	4,663,282	2.35	2,767,006	0.95	242,288,936	1.10	16,283	1.80	19,247	2.13	113.6	1.87	102.8	1.58
1988	48,891	1.85	5,067,453	2.55	2,768,393	0.95	244,499,004	1.11	17,660	1.95	20,726	2.29	118.3	1.95	106.9	1.65
1989	52,771	2.00	5,385,776	2.71	2,770,590	0.95	246,819,222	1.12	19,047	2.10	21,821	2.41	124	2.05	112.2	1.73
1990	55,876	2.12	5,674,013	2.86	2,781,018	0.95	249,622,814	1.14	20,092	2.22	22,730	2.52	130.7	2.16	116.3	1.79
1991	57,677	2.19	5,857,335	2.95	2,797,613	0.96	252,980,941	1.15	20,617	2.28	23,153	2.56	136.2	2.25	116.5	1.80
1992	61,313	2.32	6,174,369	3.11	2,818,401	0.97	256,514,224	1.17	21,755	2.40	24,070	2.66	140.3	2.32	117.2	1.81
1993	62,709	2.38	6,453,455	3.25	2,836,972	0.97	259,918,588	1.18	22,104	2.44	24,829	2.75	144.5	2.38	118.9	1.83
1994	69,150	2.62	6,865,513	3.46	2,850,746	0.98	263,125,821	1.20	24,257	2.68	26,092	2.89	148.2	2.45	120.4	1.86
1995	71,905	2.73	7,232,722	3.64	2,867,373	0.98	266,278,393	1.21	25,077	2.77	27,162	3.01	152.4	2.51	124.7	1.92
1996	77,244	2.93	7,659,651	3.86	2,880,000	0.99	269,394,284	1.23	26,821	2.96	28,433	3.15	156.9	2.59	127.7	1.97
1997	81,923	3.10	8,237,994	4.15	2,891,119	0.99	272,646,925	1.24	28,336	3.13	30,215	3.34	160.5	2.65	127.6	1.97
1998	83,769	3.17	8,679,657	4.37	2,902,872	1.00	275,854,104	1.26	28,857	3.19	31,465	3.48	163	2.69	124.4	1.92
1999	86,531	3.28	9,201,137	4.63	2,917,634	1.00	279,040,168	1.27	29,658	3.28	32,974	3.65	166.6	2.75	125.5	1.93
2000	90,815	3.44	9,749,104	4.91	2,928,435	1.00	282,192,162	1.28	31,011	3.43	34,548	3.82	172.2	2.84	132.7	2.04
2001	92,891	3.52	10,058,156	5.06	2,931,593	1.01	285,102,075	1.30	31,686	3.50	35,279	3.90	177.1	2.92	134.2	2.07
2002	97,810	3.71	10,412,244	5.24	2,934,776	1.01	287,941,220	1.31	33,328	3.68	36,161	4.00	179.9	2.97	131.1	2.02
2003	102,400	3.88	10,923,849	5.50	2,941,976	1.01	290,788,976	1.32	34,807	3.84	37,566	4.16	184	3.04	138.1	2.13
2004	114,269	4.33	11,649,827	5.87	2,954,451	1.01	293,655,404	1.34	38,677	4.27	39,672	4.39	188.9	3.12	146.7	2.26

Data from the U.S. bureaus of economic analysis, census, and labor statistics

Figure 4 compares the relative rates of change between Iowa and U.S. GSP statistics. These indices (which are calculated and included in Table 3) were generated by dividing the data for any year-area by the 1977 data for that area. As a result, the starting (1977) point for each series is fixed at 1.0 (one), and trends are easily compared on the same scale.

Figure 4. Rate of Gross State Product Growth 1977-2005

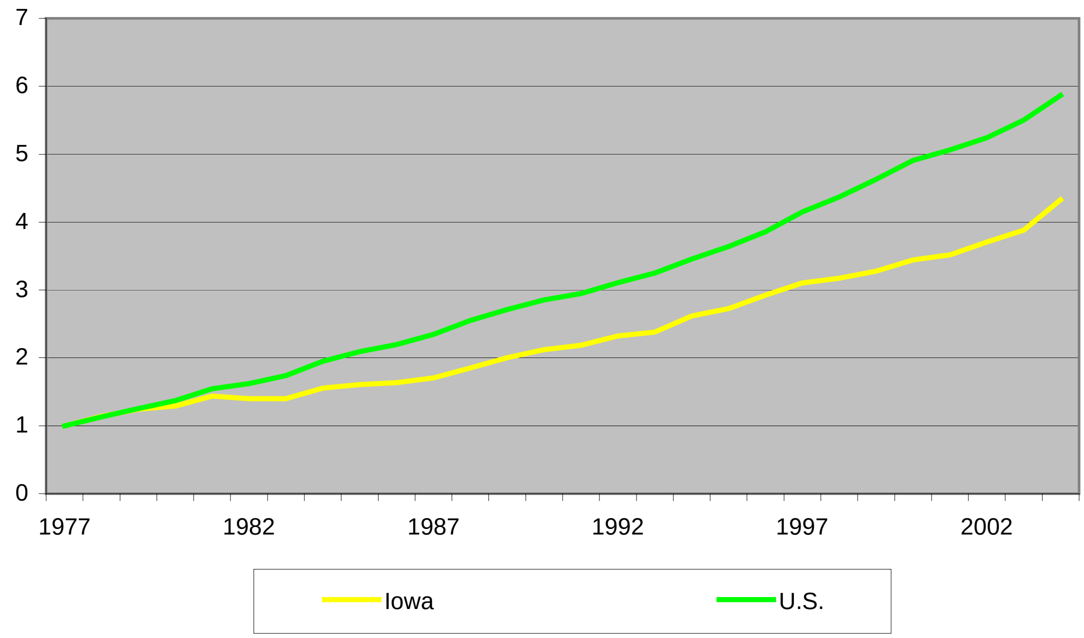


Figure 4 clearly shows a divergence between the growth trend, nationwide, and the growth trend in Iowa. This is an often-presented result that appears to show that the Iowa economy is failing over the long run. A quick look back at Table 3 will begin to dispel this assumption. The population index columns in Table 3 show that the Iowa population has held relatively constant over the period shown, while the U.S. population has increased by about 34 percent. If we apply this to the GSP trends, dividing GSP by the relevant populations for each region and year, and then index the result as above, the result is Figure 5.

Figure 5. Rate of Gross State Product Per Capita Growth 1977-2005

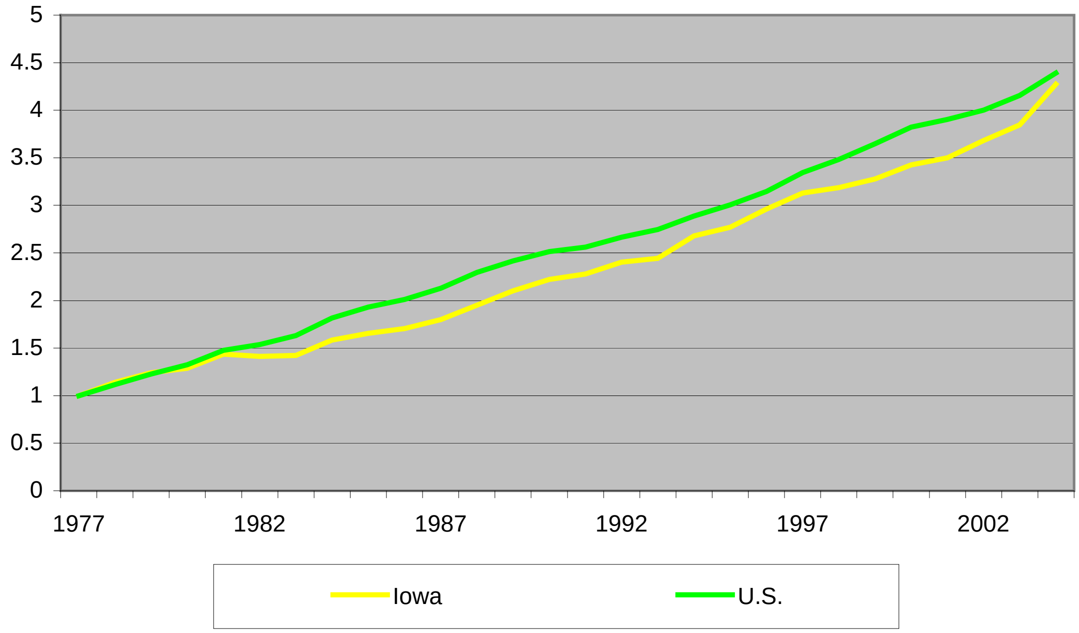


Figure 5 shows a per capita GSP trend where Iowa closely tracks the nation for most years. Iowa's position below the U.S. for most of the period directly coincides with a three-year flat spot in the Iowa trend from 1981 through 1983 that resulted from a general economic slowdown in the nation, as a whole, as well as a massive revaluation of farm assets (the farm crisis) that was experienced disproportionately in states, like Iowa, with strong agricultural production industries. Other than the shift caused by this flat spot, Iowa has closely tracked the nation over time, with a brief divergence and recovery in 1993-94, and a slow sustained divergence from 1997 through 2001. From 2002 through 2004, however, Iowa has largely closed both the recent divergence and the farm crisis trend shift. Whether this closure of the gap is temporary or will be sustained remains to be seen.

The importance of this is that the economy is made up of people. While policy makers often look at Figure 4 and conclude that something is amiss, Figure 5 shows that over time Iowa's economy is performing at a level comparable to the nation's. While there are currently concerns regarding the steady state of Iowa's population[3], there is clearly room for reasonable people to disagree as to whether this is a good or a bad thing. The population discussion should not detract from our understanding of the productivity of the Iowa economy over time.

The composition of energy consumption by fuel source is also affected by the changing structure of the Iowa economy. Over the last half century the growth in manufacturing has resulted in a decline in Iowa's reliance on agricultural production (farming).[4] The rise in manufacturing has, however, had a large ag-related component in the forms of machinery manufacturing and food

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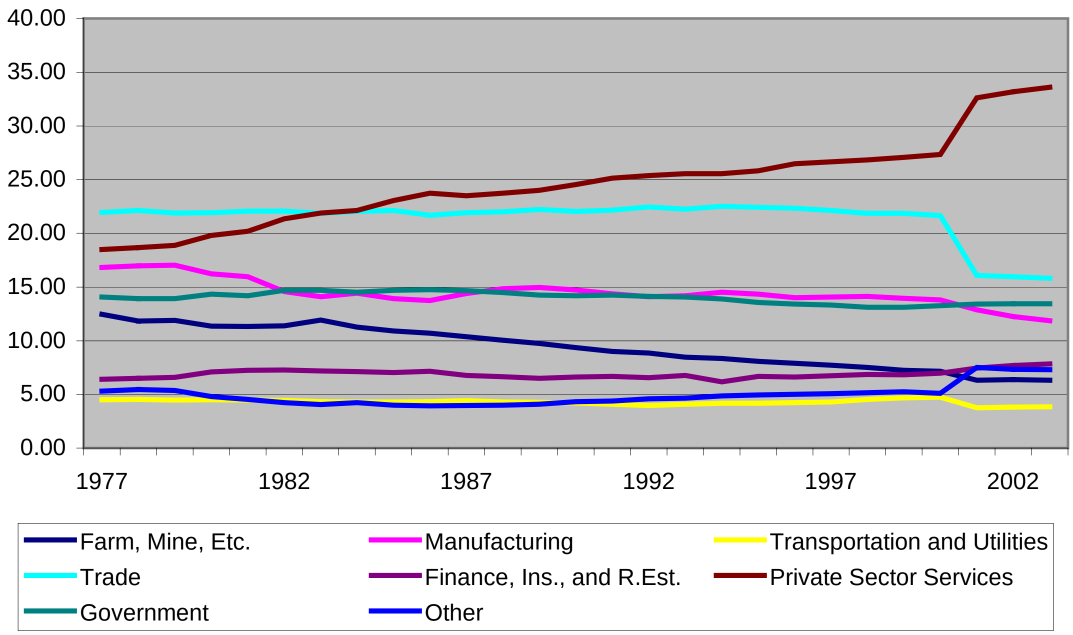
[3] The 10 metro counties in Iowa are performing comparable to U.S. averages for population and income growth while rural areas continue to lose population numbers.

[4] This is a decline in the reliance on ag production rather than a decline in ag production. Reliance declines as other sectors expand. Ag production has not declined, but as a fixed resource activity, it has limited room to grow. As the nonfarm sectors of the economy grow, relative dependence upon ag production declines even as ag production remains strong.

processing. At the same time, the mechanization of agricultural production shifted agricultural energy demand from homegrown feed and fodder crops to purchased petroleum. More recently, financial services and other services have been major growth industries in terms of jobs generated. This reflects changes in household labor force decisions and specialization of efforts and facilities within industry.

Industry shares of Iowa and U.S. total employment are shown in Figures 6 and 7.[5] Figures 8 and 9 show relative rates of employment growth for each of these industries (indexed the same way the GSP data was indexed, above).

Figure 6. Industry Employment as a Percent of Iowa Total, 1977-2003



[5] Discontinuities in Figures 6, 7, 8, and 9 between 2000 and 2001 reflect the federal change from the Standard Industrial Classification (SIC) to the North American Industrial Classification System (NAICS). This transition moved many facilities and their employees between classifications and changed some of the underlying assumptions that drove the classification process (making reconciliation extremely difficult). These discontinuities do not reflect changes in economic performance.

Figure 7. Industry Employment as a Percent of U.S. Total, 1977-2003

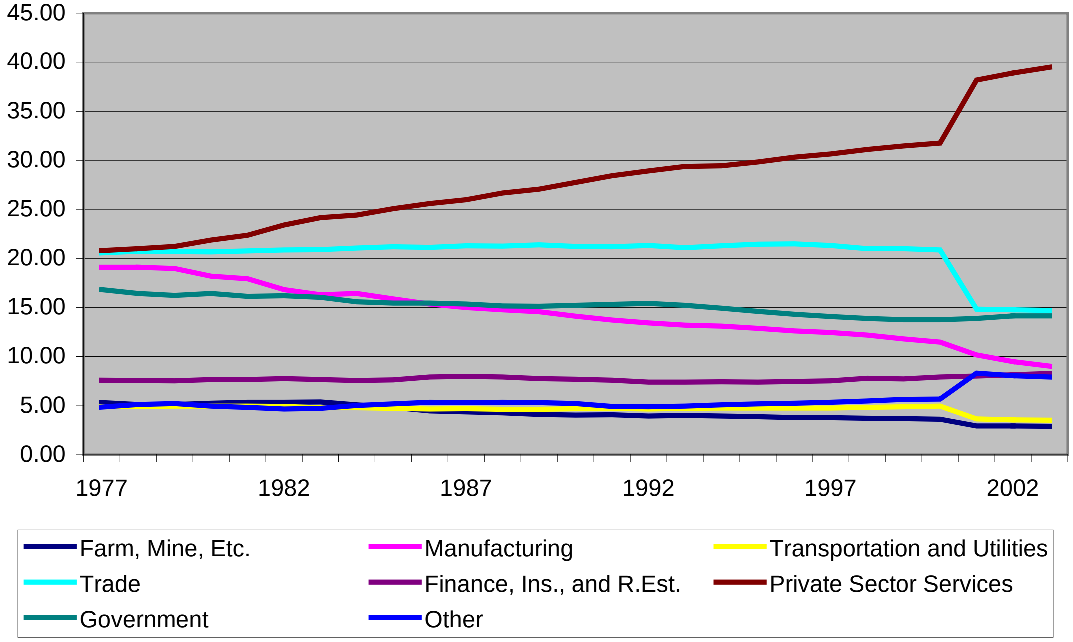


Figure 8. Relative Employment Change in Iowa Industries, 1977-2003

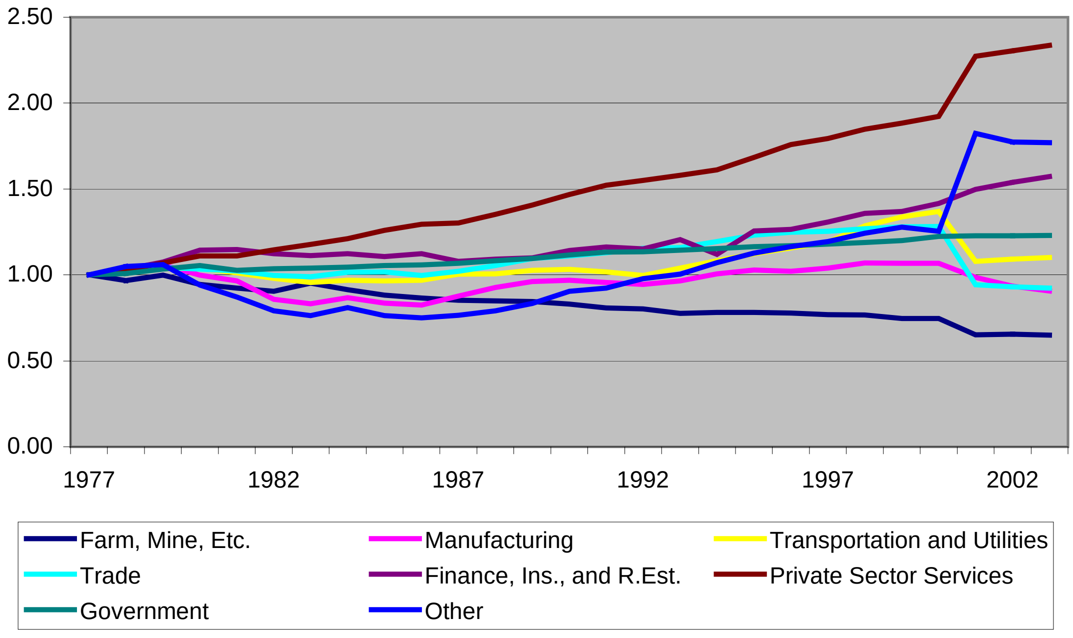
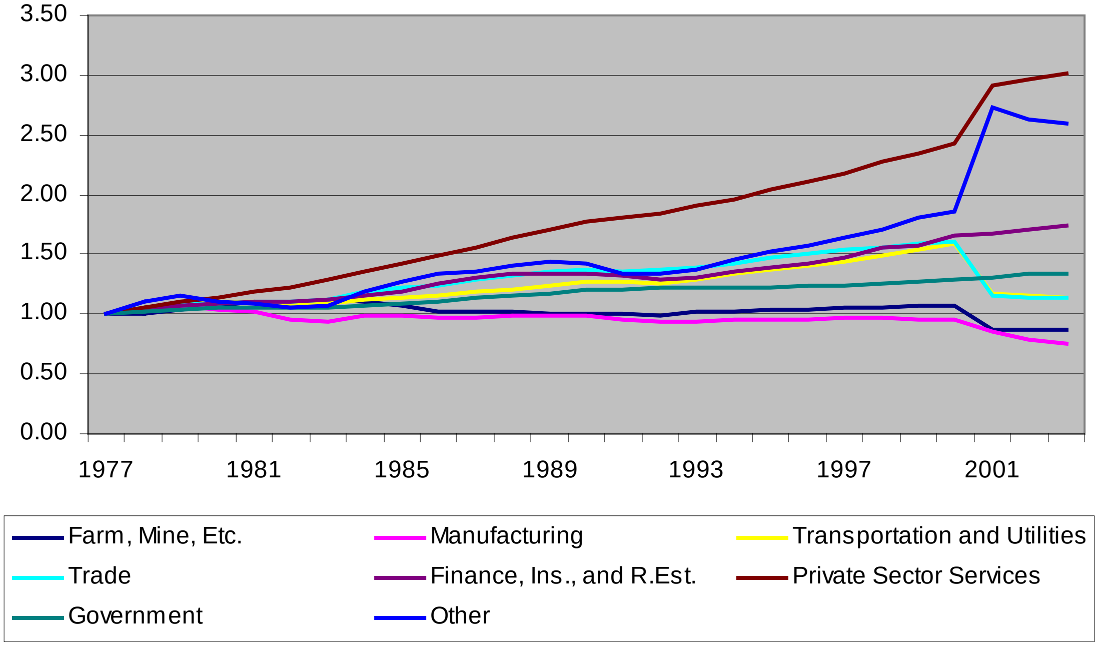


Figure 9. Relative Employment Change in U.S. Industries, 1977-2003



Note that falling employment shares in figures 6 and 7 do not always reflect falling employment in Figures 8 and 9. Falling shares can result from employment growth in an industry if that growth is not as rapid as employment growth for the area as a whole. In general, these graphs show that Iowa is looking at the same continuous economic transitions and specialization that all viable modern economies experience. The analysis on forward linkages in the next section provides information on the magnitude of energy purchases by general sectors of the economy relative to other inputs.

Iowa Energy Expenditures

Energy expenditures depend upon both the amount of energy consumed and the price of that energy per unit. Energy consumption has increased for nearly all energy sources in Iowa from 1970 to 2001. Energy prices fluctuate among energy sources. It is possible for consumption to increase while expenditures decline if prices per unit decline sufficiently.

Table 4 provides levels of expenditure for energy used in Iowa. These statistics were obtained from the U.S. Department of Energy, which applied average price per BTU to the number of BTUs consumed (Table 2) in Iowa for each energy category. In 1984, an estimated $5.45 billion, in current dollars, was spent on energy in Iowa. In 2001, the aggregate expenditure for these fuel types had grown to $8.16 billion, also in current dollars. The growth represents an increase in price as well as increase in quantity consumed.

Table 4. Estimated Iowa Energy Expenditures, 1970-2001, in Millions of Unadjusted Dollars

			Petroleum											
Year	**Steam Coal**	**Natural Gas**	**Dist. Fuel**	**Jet Fuel**	**LPG [a]**	**Motor Gas.**	**Resid. Fuel**	**Other [b] Petrol.**	**Total Petrol.**	**Nuclear Fuel**	**Wood and Waste**	**Electric Power Sector [c,d]**	**Elect.**	**Total Energy [c,d]**
1970	48.1	190.2	80.7	3	66.2	530.1	1.5	49	730.5	—	3.7	-50.4	337.5	1,259.60
1971	49.9	201	87.7	2.9	66.1	569.1	1.9	49.9	777.5	—	3.9	-59	368.3	1,341.60
1972	60	230	93.9	3.2	78.8	601.2	2.4	53.8	833.3	—	4.2	-70	412.6	1,470.20
1973	71.2	257.7	122.8	3.7	121.4	680.8	3	56.3	988	—	4.6	-80.5	451	1,691.90
1974	88.4	283.1	199.6	6.7	149.3	836.7	7.6	86.6	1,286.40	2.9	5	-100.6	508.2	2,073.30
1975	125.1	332.4	207.6	9.8	152.2	942.1	7.2	84.6	1,403.50	6.3	5.1	-132.5	624.4	2,364.30
1976	165.2	375.8	235.2	12.3	219.2	1,033.70	10.6	127.5	1,638.50	7	5.6	-162.4	709.9	2,739.50
1977	200	437.4	283.1	15.2	245.8	1,122.00	14	147.9	1,827.90	8.4	6	-194.8	824	3,108.80
1978	249	451.2	308.6	18.4	228	1,165.30	11.5	170.3	1,902.10	4.5	6.5	-232.1	926.5	3,307.80
1979	282	644	538.6	23.6	242.5	1,465.10	18.5	250.3	2,538.60	9.9	6.7	-258	1,045.30	4,268.50
1980	332.9	719.9	594.5	29.6	228.5	1,853.20	8.3	315.3	3,029.50	10.9	37.9	-313.1	1,184.50	5,002.50
1981	386.8	831.7	633.8	30.6	212	1,993.70	2.4	283.4	3,155.90	12.9	40.9	-352.6	1,433.50	5,508.90
1982	393.1	963.8	692.1	25.6	263	1,843.20	7.7	227.3	3,058.90	13.5	40.3	-356	1,561.90	5,675.50
1983	413.7	1,025.30	569.6	22.3	295.9	1,615.30	4.9	198.6	2,706.50	17	44.2	-387.6	1,745.10	5,564.20
1984	391.8	1,071.60	635.1	22.5	170.1	1,580.80	4.4	219.7	2,632.60	23	44.2	-367.3	1,653.20	5,449.20
1985	406.3	1,003.40	601	20.9	231.3	1,566.00	4.7	214.1	2,637.90	19.3	43.5	-389.3	1,666.60	5,410.60
1986	369.6	851.8	514.7	14.5	238	1,174.70	9.1	150.1	2,101.20	23.9	28.7	-334.7	1,731.10	4,771.60
1987	374.1	713.4	566.4	18.7	134	1,225.70	1.8	139.7	2,086.40	18.7	28.1	-325.6	1,687.40	4,582.60
1988	389.4	874.1	534	16.5	143.5	1,258.90	3.9	146.9	2,103.70	22.7	29.1	-353.8	1,731.00	4,796.30
1989	395.5	777.2	575.3	19.3	183.8	1,436.50	2.6	131.5	2,349.00	22.3	15.9	-348.4	1,695.00	4,906.40
1990	389	805.1	691.7	30.7	137.7	1,561.20	1.8	137.1	2,560.20	21.1	22.3	-346.5	1,744.60	5,195.90
1991	400.2	835.4	589.7	26.1	200	1,553.30	1.4	134.9	2,505.40	28.5	22.1	-358.1	1,829.00	5,262.50
1992	375.6	955.2	625	21.6	248.9	1,453.20	1.5	139.5	2,489.60	20	21	-335	1,807.20	5,333.70
1993	368.3	1,084.00	637	18.3	486.5	1,446.00	2.2	143.9	2,733.80	20.5	19.3	-333.9	1,915.50	5,807.50
1994	369.7	1,081.10	666.5	21.5	407.4	1,549.90	2.4	158.1	2,805.80	28.3	19.7	-334.4	1,957.50	5,927.80
1995	392.4	1,004.40	684.5	25	455.2	1,571.30	1.4	153.9	2,891.40	28.8	20.3	-354.4	2,069.20	6,052.10
1996	393	1,157.70	884	23.6	370.6	1,794.70	1.7	199.2	3,273.80	29.5	23.5	-339.7	2,078.50	6,616.30
1997	400.9	1,218.70	837.7	21.5	327.9	1,760.60	1.4	214.6	3,163.60	28.1	18.7	-348.8	2,156.80	6,640.10
1998	403.3	998	709	24.4	409.3	1,543.50	1.5	193.8	2,881.60	24.2	16.6	-363.5	2,254.60	6,215.80
1999	393.7	1,070.80	782.1	21.8	519.9	1,671.80	1.7	216.6	3,213.90	22.8	17.1	-342.5	2,255.00	6,631.30
2000	405.2	1,453.30	1,073.70	30.5	833.1	2,235.20	2.9	258.5	4,433.90	28.5	16.8	-367.4	2,318.80	8,289.00
2001	402.7	1,592.90	1,039.00	27.6	677.8	2,129.50	0.9	209.8	4,084.70	25	15.8	-368.7	2,408.00	8,160.50

a Liquefied petroleum gases.

b "Other" includes asphalt and road oil, aviation gasoline, kerosene, lubricants, petroleum coke (industrial and electric power), and "other petroleum products".

c There are no direct fuel costs for hydroelectric, geothermal, wind, photovoltaic, or solar thermal energy.

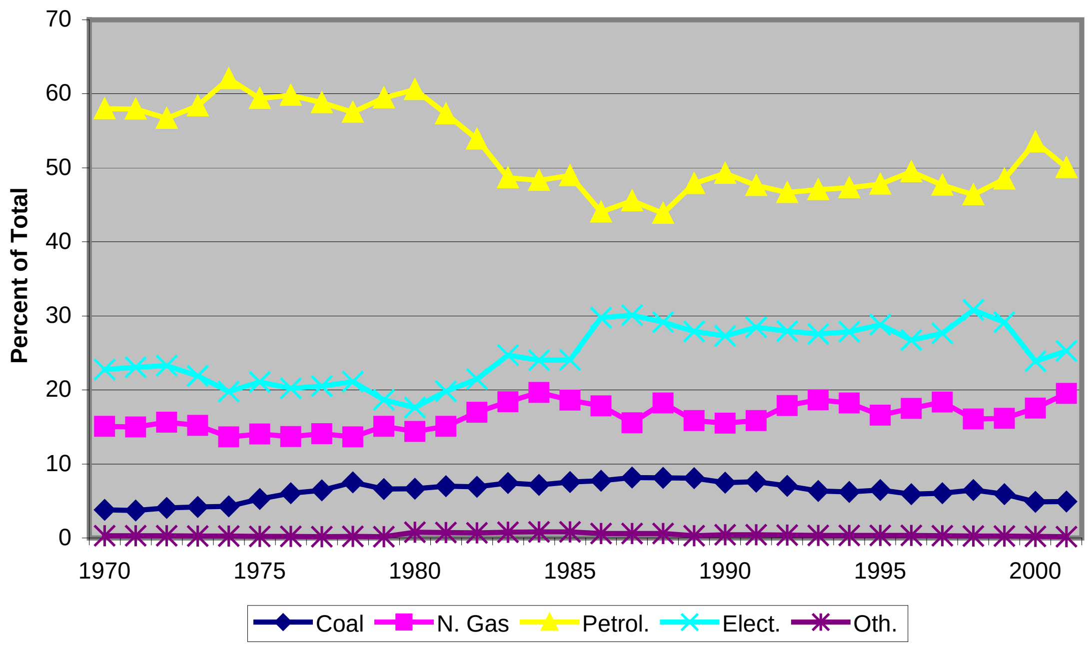
d Net imports of electricity are included in this total but not shown separately.

e There is a discontinuity in this time series between 1988 and 1989 due to the expanded coverage of the use of wood and waste beginning in 1989.

Data from the U.S. Department of Energy, Energy Information Administration

Figure 10 shows energy expenditure shares by energy source for Iowa from 1970 to 2001. As a share of annual energy expenditures, petroleum declined over the period, while both electricity and natural gas increased. Coal ended the period with nearly the same share that it had at the beginning.

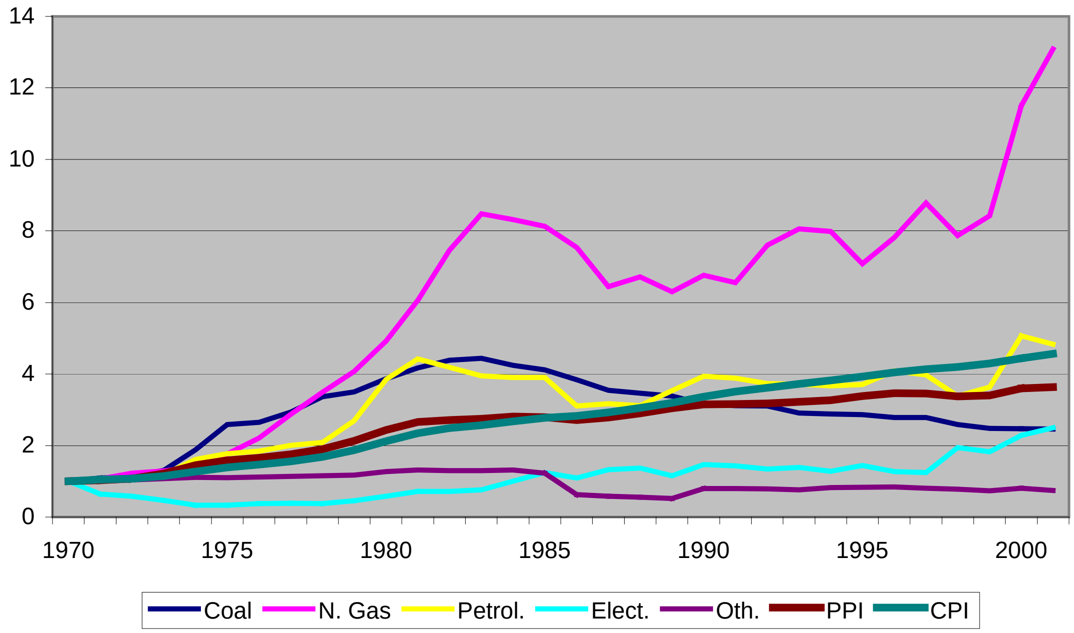
Figure 10. Iowa Energy Expenditures as Percents of Total



The increasing share of natural gas expenditures shown in Figure 10 is primarily price dependent. Table 1 shows that natural gas consumption actually decreased over the period while total energy expenditures for this fuel increased. Figure 11 shows that nominal natural gas prices in 2001 were approximately 13 times the level that they were at in 1970.

Figure 11 shows indices of nominal price changes per BTU for these energy sources, as well as indices showing changes in the levels of the Consumer Price Index (CPI) and the Producer Price Index (PPI) from Table 3. Only natural gas and petroleum prices increased more than both of the price indices over the period, and only natural gas prices significantly broke away from the general price level on the high side. Both coal and petroleum showed substantial price increases from the mid 1970s through 1982, when both began trending back towards the general price index levels. Coal's price has continued to decline below index levels while petroleum fluctuated around the CPI level from 1986 to 2001. The decreasing price of coal explains how coal can have an increasing consumption share and a flat expenditure share for the 1970-2001 period.

Figure 11. Price Level Changes Relative to CPI and PPI



Macke and Associates: 1986 Study of Energy Expenditures and Expenditure Leakages from the Iowa Economy

A study by Macke and Associates took a similar look at energy usage patterns in the Iowa economy for 1984. The energy bill in current dollars for oil, electricity, and natural gas reported by this study for 1984 was about $4.3 billion. This is substantially below the U.S. Department of Energy value reported in Table 4 for the same year ($5.45 billion). The difference reflects rapid improvements that have occurred in energy reporting, information storage, and information access that have occurred since the time of the Macke study. While Macke and Associates had to painstakingly estimate numbers for each energy source and sector, modern reporting systems and regional economic models provide a much more detailed and accurate baseline that is far more accessible.

Nevertheless, the Macke and Associates estimates of energy expenditure composition are approximately comparable to the current mix of energy sources. About 49 percent of Iowa's energy dollars go for petroleum fuels, about 30 percent for electricity and 21 percent for natural gas.   Based on Macke and Associates' methodology and weighting across the different fuel types, an estimated 79 percent of the Iowa's energy expenditures were leaving (or leaking out of) the state (Macke 1986). Natural gas leakages (expenditures that went to out-of-state recipients) were estimated as 89 percent of total expenditures for natural gas consumption in Iowa, oil leakages as 85 percent, and electricity leakages as 66 percent. These estimates appear to be relatively high based on current knowledge. It is quite possible that Macke and Associates relied too heavily on the percentage of raw energy commodities imported into Iowa when making their allocations to leakage. Current tools and information provide a better picture of the service and distribution activities that accompany energy consumption.   The value of these activities largely remains in state, reducing current estimates of energy expenditure leakage from the economy.

Estimating Energy Supply, Utilization, and Sources

In 1984, the Macke report needed to manually track through the various levels of the energy chain for each fuel type and assess the expenditure share staying in state and the share leaking out. A number of websites and reports now make it much easier to track energy usage patterns for individual states. The Energy Information Administration of the US Department of Energy provides detailed historical data for all states on energy consumption and expenditures. The periodic Iowa Energy Plan further adapts and elaborates this data for Iowa while discussing strategies. However, neither of these sources assesses the sources of energy used in Iowa and the in-state versus out of state expenditures associated with Iowa's energy needs.

Our evaluation of Iowa's energy production and consumption considers four energy resources:

- Natural gas
- Petroleum
- Electricity
- Renewables

In the case of the first three major energy sources, most of the energy resource needs are imported. Ethanol and renewable fuels such as wind generation are a small, but growing percentage of the Iowa energy picture.

In this study we complement these secondary data sources with the use of the IMPLAN Input-Output model to evaluate linkages and to estimate the leakages from the Iowa economy from spending on energy. The total energy consumption in the Iowa economy, as presented in Table 2 for electricity, natural gas and petroleum, can be allocated to detailed individual industrial sectors by looking at links to the energy sectors. Energy purchases in different forms are just one of the inputs used by businesses to produce their output. Various Census reports collected every five years provide data to estimate the relationship of input purchases to output levels for industries in the US economy.

The task of identifying imports and exports of energy is simplified in our study because the IMPLAN I-O modeling system[6] is built from data sets that use data generated through the national economic accounts, industry reports, and available administrative and enumerative data on a federal, state, and local level on average energy purchases by each sector in each state and

[6] While the details of a working I-O model can be quite complex, conceptually, an I-O model is quite simple. An I-O model is basically a matrix of economic sectors. Sectors along one axis represent industrial inputs or suppliers to the industries on the other axis, which represent industrial users or demanders. Suppliers and demanders are connected by an interlocking set of mathematical relationships specifying how much of each input is required to make a unit of any output. When an industry decides how much final output it will produce, the model specifies how much of all necessary inputs are required (alternatively, input availability could be used to determine how much final output could be produced). Conceptually, it starts out looking like the large system of mileage charts (similar to those that you find in the back of a road atlas). Unlike the numbers in a mileage chart, however, each of the cells in an I-O model contains part of a system of production functions that is linked mathematically to all of the other cells in the model. The values of goods supplied or demanded can be changed for any of the industrial cells and the matrix system can be rebalanced, showing how that initial change affects all of the industries that supply inputs to or demand outputs from the industry altered.

local area[7]. Evaluating the flow of energy resources into a region is derived from the process of estimating regional trade flows for the different commodities produced in an economy. If a region does not produce enough of a commodity, it needs to be imported. Trade flows describe the movement of goods and services between a region and the outside world. I-O models have several ways to estimate how much of local production will be used to supply local demand, or how much needs to be imported from outside sources. The approaches include a Supply-Demand Pool method that assumes local demand will first be satisfied by local production before importing. The other widely used approach to estimating trade flow in I-O models is the Regional Purchase Coefficient (RPC) method. The RPC represents the proportion of local demand purchased from local producers. This method is based on the characteristics of the region and describes the actual trade flows for the region mathematically. The IMPLAN software generates RPCs with a set of econometrically based equations. There is a different equation for each commodity with the data to estimate values filled by the study area data.

Other than ethanol and the renewable wind energy, Iowa has very few energy resources within state. While payments for the actual energy resources such as coal, natural gas and petroleum leak out of state, the infrastructure to distribute natural gas and petroleum and to generate and distribute electricity to end users in Iowa requires considerable investment and expenditures in Iowa. Our Iowa I-O model captures these in-state elements through the accounting scheme upon which the model is based.

Energy Sector Linkages: Electricity

Tables 5 and 6 present estimates of the backwards and forward linkages of the electric generation and distribution sector in the Iowa economy.[8] The backwards, or upstream, linkages are the input purchases by the electricity producers from providers. The forward, or downstream, linkages are sales to their customers, either other businesses or final consumers. The backward linkages (Table 5) are essentially input purchases, including labor, that are necessary to produce the output of the electric sector. The column of coefficients associated with these inputs, represent the cents or percentage share that those inputs contribute to each $1 dollar of electricity production. For example, the main energy source for electricity generation is coal, which is purchased from the mining sector. The coefficient value of .12 means that 12 percent of the final value of electricity is the coal. If we consider only purchased inputs, coal represents about 40 percent of these inputs. Labor represents about 17.5 percent of the total cost. The larger the coefficient, the more important it is in the production process.

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[7] The most recently available IMPLAN datasets (2002) were used in this study. IMPLAN is a point-in-time model that assumes all physical and price relationships are locked in place at that point in time. Relationships and output ratios derived from IMPLAN output can change from year to year as relative price levels change and as the technologies of production and input utilization change.

[8] The aggregation scheme used in Tables 5-10 is the basic 2-digit NAICS available in the IMPLAN library with the three energy sectors pulled out for special attention. The IMPLAN library also has a 3-digit NAICS aggregation plan available. These aggregation schemes provide a general level of detail on the interaction among sectors in the economy. IMPLAN also allows a custom aggregation of sectors, or the reports could easily be generated without any aggregation scheme.

Table 5. Input (Backward) Linkages of the Electric Generation and Distribution Industry in Iowa

Total Industry Output 2.408 Billion Dollars

Input Source Industries	Gross Coefficient	Est. $ Value Total Inputs	RPC	Regional Coefficient	Est. $ Value Local Inputs
Ag, Forestry, Fish & Hunting	0.000002	4,816	0.739780	0.000001	2,408
Mining	0.119980	288,911,840	0.008753	0.001050	2,528,400
Power generation and supply	0.000090	216,720	0.822700	0.000074	178,192
Utilities	0.000936	2,253,888	0.789866	0.000740	1,781,920
Construction	0.016507	39,748,856	0.912112	0.015056	36,254,848
Manufacturing	0.026552	63,937,216	0.699301	0.018568	44,711,744
Petroleum refineries	0.007186	17,303,888	0.035712	0.000257	618,856
Wholesale Trade	0.006270	15,098,160	0.742700	0.004657	11,214,056
Transportation & Warehousing	0.052365	126,094,920	0.726485	0.038042	91,605,136
Retail trade	0.000459	1,105,272	0.940159	0.000431	1,037,848
Information	0.002346	5,649,168	0.230659	0.000541	1,302,728
Finance & insurance	0.012199	29,375,192	0.610662	0.007449	17,937,192
Real estate & rental	0.006872	16,547,776	0.563357	0.003872	9,323,776
Professional- scientific & tech svcs	0.026758	64,433,264	0.548886	0.014687	35,366,296
Management of companies	0.000656	1,579,648	0.259308	0.000170	409,360
Administrative & waste services	0.006581	15,847,048	0.590067	0.003883	9,350,264
Educational svcs	0.003143	7,568,344	0.799800	0.002514	6,053,712
Arts- entertainment & recreation	0.000256	616,448	0.843719	0.000216	520,128
Accommodation & food services	0.005423	13,058,584	0.887093	0.004811	11,584,888
Other services	0.001288	3,101,504	0.827903	0.001067	2,569,336
Government & non NAICs	0.000186	447,888	0.882333	0.000164	394,912
Total Commodity Demand	0.296057	712,905,256		0.118251	284,748,408

Value Added	Coefficients	Value Added
Indirect Business Taxes	0.115532	278,201,056
Other Property Income	0.380242	915,622,736
Proprietary Income	0.032983	79,423,064
Employee Compensation	0.175187	421,850,296
Total Value Added	0.703943	1,695,094,744

Data from MIG IMPLAN

Table 5 notes

Gross coefficient is the production function value (input value per dollar of electric output production) prior to adjustment for imports to the region.

Estimated $ value total inputs is the value of inputs required for the electricity produced in the region (gross coefficient times the electric production in the region) prior to adjustment for imports.

RPC is the regional purchase coefficient or the share of required inputs provided from local sources.

Regional coefficient is the input value per dollar of electric production, after adjusting for imports

Estimated $ value of local inputs is the RPC times the gross coefficient which provides an estimate of the value of locally provided inputs.

Table 6. Output (Forward) Linkages of the Electric Generation and Distribution Industry in Iowa

Total Industry Output 2.408 Billion Dollars

Output Demand Industries	Gross Coefficient	Tot. $ Value of Elect. Input	RPC	Regional Coefficient	Local $ Value Elect. Input
Ag, Forestry, Fish & Hunting	0.014755	35,530,040	0.822700	0.012139	29,230,712
Mining	0.015723	37,860,984	0.822700	0.012935	31,147,480
Electricity	0.000090	216,720	0.822700	0.000074	178,192
Natural gas	0.000539	1,297,912	0.822700	0.000443	1,066,744
Water,sewer	0.011280	27,162,240	0.822700	0.009280	22,346,240
Construction	0.004226	10,176,208	0.822700	0.003477	8,372,616
Manufacturing	0.013279	31,975,832	0.822700	0.010925	26,307,400
Wholesale Trade	0.006196	14,919,968	0.822700	0.005097	12,273,576
Transportation & Warehousing	0.005137	12,369,896	0.822700	0.004226	10,176,208
Retail trade	0.011815	28,450,520	0.822700	0.009720	23,405,760
Information	0.004873	11,734,184	0.822700	0.004009	9,653,672
Finance & insurance	0.003615	8,704,920	0.822700	0.002974	7,161,392
Real estate & rental	0.021629	52,082,632	0.822700	0.017794	42,847,952
Professional- scientific & tech svcs	0.003609	8,690,472	0.822700	0.002969	7,149,352
Management of companies	0.014964	36,033,312	0.822700	0.012311	29,644,888
Administrative & waste services	0.007939	19,117,112	0.822700	0.006531	15,726,648
Educational svcs	0.006592	15,873,536	0.822700	0.005424	13,060,992
Health & social services	0.008438	20,318,704	0.822700	0.006942	16,716,336
Arts- entertainment & recreation	0.019089	45,966,312	0.822700	0.015705	37,817,640
Accommodation & food services	0.026760	64,438,080	0.822700	0.022016	53,014,528
Other services	0.014427	34,740,216	0.822700	0.011869	28,580,552
Government & non NAICs	0.002400	5,779,200	0.822700	0.001974	4,753,392
Total Industry Demand		523,439,000			430,632,272

Data from MIG IMPLAN

Table 6 notes
Gross coefficient is the input value per dollar of electric production provided to each industry in the region, prior to adjustment for imports.
Total $ value of inputs is the gross coefficient times the industry purchases.
RPC is the regional purchase coefficient or the share of required inputs provided from local sources.
Regional coefficient is the input value per dollar of electric production, after adjusting for imports.
Estimated $ value of local inputs is the regional coefficient times the total $value of electric production used as inputs by other industries in the region.

The extremely low RPC of .009[9] for coal indicates that less than one percent of the raw energy material for producing electricity comes from Iowa sources. While a large share (27.4 percent) of the transportation cost also goes to out-of-state shippers, most is captured in the Iowa economy as indicated by an RPC value of .726. Labor costs and returns to capital are a major component of

[9] The RPC of 0.009 is used for mining, generally, in Iowa throughout the IMPLAN IO model. It will appear again in Tables 7 (Natural Gas) and 9 (Petroleum). Given that the amount of coal mined in Iowa is miniscule and no natural gas and petroleum is recovered in Iowa, these input lines could reasonably be interpreted as zero and the dollar values could be eliminated also. This course of action is not explicitly taken in the tables, as that would imply that we were able to rebalance the coefficients for all other industries to capture this deduction. It would be safer to assume that the estimation process that generates the excess in this sector also generates some deficiencies in other sectors, and that, overall, these aberrations net to zero in the total sum.

the cost of production. These are value-added components, summing to 56 percent of output value and occur in Iowa. While the leakage factor is very high for the raw energy material (mostly coal), overall leakage for electricity is reduced by including the full range of expenditures in energy production and distribution rather than just expenditures for industrial and mining inputs. The last column in Table 5 represents an estimate of the value of inputs that are purchased from in-state sources. While coal is an important input, very little comes from in-state sources.

Table 6 details direct sales of electricity from generators to other industrial consumers (input sales) in sectors of the Iowa economy. These direct input sales account for 22 percent of electricity consumed in Iowa. When we include indirect sales to other industrial users, the inter-industry sectors are the largest consumers of electricity with about 44 percent of total purchases. All households consume about 27 percent, which is comparable to the amount estimated in the EIA reports for the residential sector. The remaining balance is allocated into the public sectors of the model.[10]

Energy Sector Linkages: Natural Gas

Tables 7 and 8 present estimates of backward and forward linkages to the natural gas sector. Unlike electric power, activities in the Iowa natural gas sector are primarily distribution functions, which require extensive staffing nonetheless. The backward linkages indicate that the main industrial linkage is into the oil and drilling industries of the mining sector. According to the I-O tables, input purchases of natural gas represent 46 percent of the total costs to consumers. As related to natural gas extraction, these activities are negligible in Iowa. According to the RPC in our I-O model, less than 1 percent of the fuel supply comes from Iowa sources. Other major activities such as the wholesale and warehousing have a greater share of their activity occurring in Iowa so that the input purchases from Iowa sources in the inter-industry sectors amount to 23 percent of the inter-industry input purchases. The remaining 77 percent is imported from out of state, or is considered as leakage.[11] Without any natural gas production activity in Iowa, the bulk of the in-state economic activity is involved with distribution to end-users. Labor cost for this delivery represents 14 percent of total costs of output. Payments to capital account for 7 percent of the total expenditure for natural gas in Iowa. Overall, when all of these in-state and value-added activities are included, the share of Iowa-based expenditures increases to nearly 48 percent of the total and 52 percent of Iowa natural gas expenditures constitute leakages to out of state.

It has been noted in many quarters that the majority of the corporations providing natural gas (as well as electric and petroleum) services in Iowa are headquartered outside of the state. Questions about the value of their in-state transactions generally follow. The statistics upon which this analysis is based are place-of-work statistics; meaning that the value is credited to the area where the work is done, so this is not a problem. In general, whether the firms involved are headquartered out-of-state or in-state, the majority are public stock companies. This means that the distribution of ownership interests and rewards is not tied to the location of the firms' headquarters.

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[10] Although the IMPLAN model offers an estimate of electricity consumption, we calibrate our coefficients to the numbers in the EIA report.

[11] These percentages are for interindustry input purchases, only, and do not include payments to factors of production (value-added returns). As such they are net input percentages rather than gross production percentages.

Table 7. Input (Backward) Linkages of the Natural Gas Industry in Iowa

Total Industry Output 1.593 Billion Dollars

Input Source Industries	Gross Coefficient	Est. $ Value Total Inputs	RPC	Regional Coefficient	Est. $ Value Local Inputs
Ag, Forestry, Fish & Hunting	0.000008	12,744	0.739780	0.000006	9,558
Mining	0.463030	737,606,790	0.008753	0.004053	6,456,429
Power generation and supply	0.000539	858,627	0.822700	0.000443	705,699
Natural gas distribution	0.000002	3,186	0.594781	0.000001	1,593
Utilities	0.000451	718,443	0.789866	0.000356	567,108
Construction	0.000683	1,088,019	0.912112	0.000623	992,439
Manufacturing	0.010985	17,499,105	0.699301	0.007682	12,237,426
Petroleum refineries	0.000835	1,330,155	0.035712	0.000030	47,790
Wholesale Trade	0.001355	2,158,515	0.742700	0.001007	1,604,151
Transportation & Warehousing	0.170106	270,978,858	0.726485	0.123580	196,862,940
Retail trade	0.000471	750,303	0.940159	0.000443	705,699
Information	0.000381	606,933	0.230659	0.000088	140,184
Finance & insurance	0.010864	17,306,352	0.610662	0.006634	10,567,962
Real estate & rental	0.003270	5,209,110	0.563357	0.001842	2,934,306
Professional- scientific & tech svcs	0.011563	18,419,859	0.548886	0.006347	10,110,771
Management of companies	0.000668	1,064,124	0.259308	0.000173	275,589
Administrative & waste services	0.003968	6,321,024	0.590067	0.002341	3,729,213
Educational svcs	0.002024	3,224,232	0.799800	0.001619	2,579,067
Arts- entertainment & recreation	0.000404	643,572	0.843719	0.000341	543,213
Accommodation & food services	0.001202	1,914,786	0.887093	0.001067	1,699,731
Other services	0.000710	1,131,030	0.827903	0.000587	935,091
Government & non NAICs	0.000495	788,535	0.882333	0.000436	694,548
Total Commodity Demand	0.684014	1,089,634,302	235.374000	0.159700	254,402,100

Value Added	**Coefficients**	**Value Added**
Indirect Business Taxes	0.086156	137,246,508
Other Property Income	0.071782	114,348,726
Proprietary Income	0.018824	29,986,632
Employee Compensation	0.139224	221,783,832
Total Value Added	0.315986	503,365,698

Data from MIG IMPLAN

Table 7 notes
Gross coefficient is the production function value (input value per dollar of natural gas output production) prior to adjustment for imports to the region.
Estimated $ value total inputs is the value of inputs required for the natural gas produced in the region (gross coefficient times the natural gas production in the region) prior to adjustment for imports.
RPC is the regional purchase coefficient or the share of required inputs provided from local sources.
Regional coefficient is the input value per dollar of electric production, after adjusting for imports
Estimated $ value of local inputs is the RPC times the gross coefficient which provides an estimate of the value of locally provided inputs.

Total expenditures on natural gas sum to an estimated $1.6 billion for the Iowa economy. Table 8 details direct natural gas distributor sales to industrial users (input sales). Direct sales to industries for input use amount to 5 percent of Iowa natural gas expenditures. When we add indirect sales (through futures or hedged purchases) of natural gas to industrial users, industry demand for natural gas represents about 47 percent of the total and residential accounting for about 37 percent of the total.

Table 8. Output (Forward) Linkages of the Natural Gas Industry in Iowa

Total Industry Output 1.593 Billion Dollars

Output Demand Industries	Gross Coefficient	Tot. $ Value of Nat. Gas Input	RPC	Regional Coefficient	Local $ Value Nat. Gas Input
Ag, Forestry, Fish & Hunting	0.001506	2,399,058	0.587831	0.000885	1,409,805
Mining	0.000368	586,224	0.587831	0.000216	344,088
Natural gas	0.000002	3,186	0.587831	0.000001	1,593
Water,sewer	0.006899	10,990,107	0.587831	0.004056	6,461,208
Construction	0.001034	1,647,162	0.587831	0.000608	968,544
Manufacturing	0.006046	9,631,278	0.587831	0.003554	5,661,522
Wholesale Trade	0.001728	2,752,704	0.587831	0.001016	1,618,488
Transportation & Warehousing	0.001501	2,391,093	0.587831	0.000882	1,405,026
Retail trade	0.001181	1,881,333	0.587831	0.000694	1,105,542
Information	0.000743	1,183,599	0.587831	0.000437	696,141
Finance & insurance	0.000237	377,541	0.587831	0.000140	223,020
Real estate & rental	0.003700	5,894,100	0.587831	0.002175	3,464,775
Professional- scientific & tech svcs	0.000573	912,789	0.587831	0.000337	536,841
Management of companies	0.002836	4,517,748	0.587831	0.001667	2,655,531
Administrative & waste services	0.003026	4,820,418	0.587831	0.001779	2,833,947
Educational svcs	0.001975	3,146,175	0.587831	0.001161	1,849,473
Health & social services	0.001952	3,109,536	0.587831	0.001148	1,828,764
Arts- entertainment & recreation	0.001944	3,096,792	0.587831	0.001143	1,820,799
Accommodation & food services	0.006032	9,608,976	0.587831	0.003546	5,648,778
Other services	0.004540	7,232,220	0.587831	0.002669	4,251,717
Government & non NAICs	0.000138	219,834	0.587831	0.000081	129,033
Total Industry Demand		76,401,873			44,914,635

Data from MIG IMPLAN

Table 8 notes

Gross coefficient is the input value per dollar of natural gas production provided to each industry in the region, prior to adjustment for imports.

Total $ value of inputs is the gross coefficient times the industry purchases.

RPC is the regional purchase coefficient or the share of required inputs provided from local sources.

Regional coefficient is the input value per dollar of natural gas production, after adjusting for imports.

Estimated $ value of local inputs is the regional coefficient times the total $value of natural gas production used as inputs by other industries in the region.

Energy Sector Linkages: Petroleum

Table 9 and 10 present the backward and forward linkages of the petroleum sector in the Iowa economy. The coefficients for these linkages are based on “average” values from a national survey of industry purchasing patterns. The RPCs provide the estimate of how many of the petroleum-related expenditures come from Iowa sources. Our I-O framework puts petroleum refining at the hub of the petroleum supplying function and uses margin estimates to calculate a share of value that goes to the wholesale distribution activities and a share to the gasoline and petroleum retailing function.

The backward linkages from petroleum processing, which are based on national production relationships, include the drilling and mining activities as the main input. As with natural gas and coal, very little of this primary energy source is found in Iowa, implying substantial leakages from the state to pay for the raw energy materials.

Since petroleum refining occurs at a factory level, there are several distribution and retailing levels in getting the supplies to end users and the prices paid by the final consumer reflect these additional costs. We are also able to use IMPLAN as a source of estimates of margins allocated to the wholesalers and retailers (Table 9). These values reflect the share of the consumer dollar that goes to each function and should sum to 1 in total. These coefficients can be used to allocate the $4.08 billion of petroleum expenditures to end users in the state back to its components. Using this procedure means that $1.6 billion of value goes to the refineries, $1.56 billion to the wholesale and storage functions and $887 million to retailing activities. Obviously, little of the refining activity occurs in Iowa and most of the retailing occurs in state. Also, much of the wholesaling activity, about 74 percent according to IMPLAN estimates, occurs as instate functions in the form of distribution and the pipeline and storage facilities.

The forward linkages out of petroleum processing do include a large block of sales to transportation sectors and to households. The I-O model estimates about 47 percent of the refinery sales are to other industries with the remainder to residential and government.

Table 9. Input (Backward) Linkages of the Petroleum Industry in Iowa

Total Industry Output 1.606 Billion Dollars

Input Source Industries	Gross Coefficient	Est. $ Value Total Inputs	RPC	Regional Coefficient	Est. $ Value Local Inputs
Mining	0.662740	1,064,360,440	0.008753	0.005801	9,316,406
Power generation and supply	0.010692	17,171,352	0.822700	0.008797	14,127,982
Natural gas distribution	0.012026	19,313,756	0.594781	0.007153	11,487,718
Utilities	0.000103	165,418	0.789866	0.000081	130,086
Construction	0.000804	1,291,224	0.912112	0.000734	1,178,804
Manufacturing	0.024649	39,586,294	0.699301	0.017237	27,682,622
Petroleum refineries	0.063704	102,308,624	0.035712	0.002275	3,653,650
Wholesale Trade	0.044148	70,901,688	0.742700	0.032789	52,659,134
Transportation & Warehousing	0.044499	71,465,394	0.726485	0.032328	51,918,768
Retail trade	0.000431	692,186	0.940159	0.000405	650,430
Information	0.001115	1,790,690	0.230659	0.000257	412,742
Finance & insurance	0.012794	20,547,164	0.610662	0.007813	12,547,678
Real estate & rental	0.008774	14,091,044	0.563357	0.004943	7,938,458
Professional- scientific & tech svcs	0.015846	25,448,676	0.548886	0.008698	13,968,988
Management of companies	0.011146	17,900,476	0.259308	0.002890	4,641,340
Administrative & waste services	0.003604	5,788,024	0.590067	0.002126	3,414,356
Educational svcs	0.000732	1,175,592	0.799800	0.000585	939,510
Arts- entertainment & recreation	0.000848	1,361,888	0.843719	0.000716	1,149,896
Accommodation & food services	0.003088	4,959,328	0.887093	0.002739	4,398,834
Other services	0.006996	11,235,576	0.827903	0.005792	9,301,952
Government & non NAICs	0.000762	1,223,772	0.882333	0.000673	1,080,838
Total Commodity Demand	0.929504	1,492,783,424		0.144833	232,601,798

Value Added	Coefficients	Value Added
Indirect Business Taxes	0.005209	8,365,654
Other Property Income	0.016436	26,396,216
Proprietary Income	0.029517	47,404,302
Employee Compensation	0.019333	31,048,798
Total Value Added	0.070496	113,216,576

Data from MIG IMPLAN

Table 9 notes

Gross coefficient is the production function value (input value per dollar of electric output production) prior to adjustment for imports to the region.

Estimated $ value total inputs is the value of inputs required for the petroleum produced in the region (gross coefficient times the petroleum production in the region) prior to adjustment for imports.

RPC is the regional purchase coefficient or the share of required inputs provided from local sources.

Regional coefficient is the input value per dollar of petroleum production, after adjusting for imports

Estimated $ value of local inputs is the RPC times the gross coefficient which provides an estimate of the value of locally provided inputs.

Table 10. Output (Forward) Linkages of the Petroleum in Iowa

Total Industry Output 1.606 Billion Dollars

Output Demand Industries	**Gross Coefficient**	**Tot. $ Value of Petro. Input**	**RPC**	**Regional Coefficient**	**Local $ Value Petro. Input**
Ag, Forestry, Fish & Hunting	0.019006	30,523,636	0.035712	0.000679	1,090,474
Mining	0.008201	13,170,806	0.035712	0.000293	470,558
Power generation and supply	0.007186	11,540,716	0.035712	0.000257	412,742
Natural gas distribution	0.000835	1,341,010	0.035712	0.000030	48,180
Utilities	0.004549	7,305,694	0.035712	0.000162	260,172
Construction	0.009622	15,452,932	0.035712	0.000344	552,464
Manufacturing	0.005002	8,033,212	0.035712	0.000179	287,474
Petroleum refineries	0.063704	102,308,624	0.035712	0.002275	3,653,650
Wholesale Trade	0.001808	2,903,648	0.035712	0.000065	104,390
Transportation & Warehousing	0.040172	64,516,232	0.035712	0.001435	2,304,610
Retail trade	0.002004	3,218,424	0.035712	0.000072	115,632
Information	0.000360	578,160	0.035712	0.000013	20,878
Finance & insurance	0.000313	502,678	0.035712	0.000011	17,666
Real estate & rental	0.000946	1,519,276	0.035712	0.000034	54,604
Professional- scientific & tech svcs	0.000140	224,840	0.035712	0.000005	8,030
Management of companies	0.000192	308,352	0.035712	0.000007	11,242
Administrative & waste services	0.009523	15,293,938	0.035712	0.000340	546,040
Educational svcs	0.000285	457,710	0.035712	0.000010	16,060
Health & social services	0.001633	2,622,598	0.035712	0.000058	93,148
Arts- entertainment & recreation	0.001164	1,869,384	0.035712	0.000042	67,452
Accommodation & food services	0.001314	2,110,284	0.035712	0.000047	75,482
Other services	0.001626	2,611,356	0.035712	0.000058	93,148
Government & non NAICs	0.002040	3,276,240	0.035712	0.000073	117,238
Total Industry Demand		291,689,750			10,421,334

Data from MIG IMPLAN

Table 10 notes

Gross coefficient is the input value per dollar of petroleum production provided to each industry in the region, prior to adjustment for imports.

Total $ value of inputs is the gross coefficient times the industry purchases.

RPC is the regional purchase coefficient or the share of required inputs provided from local sources.

Regional coefficient is the input value per dollar of petroleum production, after adjusting for imports.

Estimated $ value of local inputs is the regional coefficient times the total $value of petroleum production used as inputs by other industries in the region.

Alternate fuels

Two major alternative fuel sources, corn-based ethanol and wind energy are becoming a significant part of the Iowa energy economy. They are also important because they rely on locally provided energy materials in the form of the corn crop and the wind flow. Solar-generated energy and non-ethanol bio-based fuels[12] currently add minor levels of energy to users in Iowa. A summary of alternative electrical usage in Iowa is presented in Table 11.

[12] Non-ethanol bio-based fuels would include fuel or petroleum substitutes derived from plant and animal material through processes other than ethanol production. This category would be primarily made up of bio-diesel (diesel fuel derived from soybeans, waste fats and oils, and other plant or animal materials or by-products).

Table 11. Solar, Wind, and Bio-based Energy

	Nameplate Capacity (kW)	% of Total Alt. Cap.	% of total Elect. Cap. (2003)*	Effective Capacity (kW)	% of Total Effective Cap. (2003)	Estimated Generation (MWh)	% of Total Elect. Sales (2002)
Biomass	19,870	2.43%	0.2%	14,903	0.2%	130,546	0.3%
Hydro	134,035	16.42%	1.4%	73,719	0.8%	645,781	1.4%
PV	86	0.01%	0.0%	17	0.0%	151	0.0%
Wind	637,110	78.07%	6.5%	191,133	1.9%	1,674,324	3.7%
Other	25,010	3.06%	0.3%	18,758	0.2%	164,316	0.4%
Total	**816,111**	**100%**	**8.3%**	**298,529**	**3.0%**	**2,615,117**	**5.8%**

* Total Electric Capacity of 9,819.17 MW, from IUB's December 2003 report, "Facts Concerning the Consumption and Production of Electric Power in Iowa" (Appendices D & E)

* Total Electric Sales to Customers from IUB's December 2003 report, "Facts Concerning the Consumption and Production of Electric Power in Iowa" (Table 1-1)

Some of the alternate energy fuel sources are achieving high levels of consumer acceptance. Ten percent ethanol blend (E10) gasoline achieved a 66 percent market share of the motor vehicle sales in Iowa in 2004. This represents 111 million gallons of ethanol. Currently, E10 gasoline has a 74 percent share of the Iowa retail gasoline market. This limits the extent to which ethanol in the form of E10 gasoline can further reduce retail expenditures upon petroleum products in Iowa.

E85 (85 percent ethanol and 15 percent petroleum gasoline) may have increased potential to function as a retail petroleum substitute. The recent rise in oil prices seem to have stimulated sales of 85 percent ethanol blend (E85) gasoline in Iowa as those sales have been rising. In 2004, over 140,000 gallons of E-85 were sold in Iowa. Sales through September 2005 have already tripled 2004 levels.

Expanded retail penetration of E85 gasoline depends upon two interrelated conditions. First, the number of vehicles that can efficiently operate on E85 gasoline must increase. Unlike E10 gasoline, E85 gasoline is not an efficient fuel in vehicle power plants that are currently standard. The lower energy content of ethanol relative to petroleum gasoline is not a critical factor in fuels containing 10 percent ethanol and 90 percent petroleum gasoline.[13] The fuel content difference between E85 gasoline and petroleum gasoline, however, is significant enough to require power plant modifications. Further penetration of E85 gasoline in the retail market depends upon continued penetration of dual-fuel power plants in the vehicle marketplace.

Second, the number of E85 gasoline outlets must expand. The limited availability of E85 gasoline in most areas reduces the incentive for motor fuel retailers to make E85 available. This inevitably leads to a chicken-and-egg situation. Over time, expansion of E85 compliant vehicles

[13] Depending upon analytical variables (speed of burn, carburetion, heat of burn, etc.) ethanol is generally reported as having energy (BTU) content of between 60 percent and 75 percent of the energy content of petroleum gasoline by volume. As a result, a gallon of E10 gasoline has 96 percent to 97.5 percent of the energy content of a gallon of petroleum gasoline. On the same basis, a gallon of E85 gasoline has 66 percent to 79 percent of the energy content of a gallon of petroleum gasoline. In the absence of any other burn characteristics or efficiency factors affecting the value of the fuel from a consumer's perspective, these energy content differences would also be expected to directly translate into fuel price discounts in the per gallon prices of ethanol-blend gasoline relative to petroleum gasoline.

in and around areas where E85 is available may result in expansions of vehicles and availability on the peripheries of these areas.

On the production side, Iowa is clearly an exporter of ethanol. Current ethanol production capacity (dry and wet milling) in Iowa is listed as 1.1 billion gallons annually. Planned construction and expansions would add an additional 400 million of additional annual capacity in the next few years. Many of the states neighboring Iowa also have sizeable ethanol production facilities. Ethanol is targeted as a motor fuel additive in major urban markets in West and East coasts where MTBE is currently being banned as a fuel additive. At current levels of production, Iowa is exporting about 800 million gallons of ethanol annually. The economic contribution to the Iowa economy associated with exporting this level of ethanol can be evaluated using an I-O model. Table 12 presents IMPLAN-based estimates of the direct and secondary effects associated with 800 million gallons of ethanol production and export.[14]

The input stream for ethanol production taps into many Iowa based inputs including corn production and processing, and transportation. The intermediate power supplies of natural gas and coal do come from out of state. IMPLAN's estimates indicate that about 55 percent of the ethanol input stream comes from in-state sources.

Interest is increasing in biodiesel as an energy source as well. Iowa currently has three biodiesel plants with the capacity to produce 21 million gallons per year. Another two plants, with a combined capacity of 31 million gallons per year, are currently under construction, and several more plants, with a combined capacity of at least 128 million gallons per year, are in the planning stages.

[14] The IMPLAN-based estimates in Table 12 are for illustrative purposes, only, and do not represent a real-world analysis of the impacts of ethanol production upon the Iowa economy over the long term. The 800 million gallon scenario cannot be summed of differenced from the 2002 IMPLAN results for other fuels presented in this report, because this level of capacity did not exist in 2002. No effort is made to analyze the import substitution effects of ethanol sold in the Iowa market, as those values are subsumed under food processing, organic chemical production, and petroleum wholesaling and retailing in the official statistics and the IMPLAN model. In addition, the IMPLAN model assumes that all markets (input and output) clear, and that new production at any level necessitates the production of new inputs at previous levels. This assumption is critical and is clearly violated by corn-based ethanol production, where surplus corn is freely available in the input market, negating a large portion of input effects generated by the model. Finally, IMPLAN assumes that production functions do not change and the economy remains in general equilibrium throughout the analysis. Ethanol production at the current rate and continued expansion of this production clearly affects a number of production relationships in broad areas of the Iowa economy, including livestock production and processing, soybean production and processing, rail and truck transportation (and the resulting fuel requirements for transportation of all goods in many areas), and grain warehousing. The ultimate effect of these changes in underlying production relationships is unknown and beyond the capacity of IMPLAN to quantify.

Table 12. Estimated Economic Impacts Associated with the Export of 800 Million Gallons of Iowa Ethanol Production

	Total Sales	Income	Jobs
Agriculture	653,911,162	8,282,083	386
Mining	474,564	56,027	3
Utilities	13,308,797	2,315,606	30
Construction	1,855,412	821,548	23
Manufacturing	1,422,862,895	33,245,519	758
Transportation & warehousing	40,821,606	14,813,903	347
Retail trade	6,938,699	3,042,218	158
Information services	2,613,579	786,738	20
Finance, insurance & real estate	16,930,828	3,741,094	140
Professional and technical services	15,797,849	8,035,018	282
Other services	13,555,601	4,076,761	235
Government	8,214,228	853,182	20
Total	2,197,285,219	80,069,697	2,402

Wind energy capacity in Iowa has also expanded rapidly in recent years. In 2004 approximately 10 million kWh of electricity was generated from wind power and entered the electricity grid. Electricity from wind represents about 4 percent of the total consumed in Iowa. Iowa currently ranks third behind California and Texas in the level of installed wind generating capacity. An attraction of generating electricity with wind turbines is the free cost of the wind energy. The wind turbines are manufactured outside the state, but the construction and subsequent operation and maintenance labor are in-state expenditures. Wind-power energy is not itemized as a separate activity in our I-O model, but an assessment of the other energy generating activities suggest that once the wind farms are operating, very little of the operating inputs are imported. Further growth of wind energy in Iowa that substitutes for currently imported energy sources will provide greater in-state economic impacts.

Assessment

Living and working in the 21st century is a high energy consuming proposition. Providing energy for transportation, for homes, businesses and industries in a clean and affordable fashion requires an extensive delivery system and a variety of alternative energy types. Through the foreseeable future, primary energy resources for Iowa's economy will continue to be supplied by minerals and petroleum extracted from the earth. In this respect, Iowa will remain a net importer of raw energy commodities in the near term. This is inevitable, as Iowa has a growing economy with no major commercially recoverable energy reserves.

While the majority of the primary, or raw energy sources, such as coal and crude oil, used to generate consumer-ready energy come from outside Iowa, there is considerable economic activity involved in getting that energy processed, converted and distributed to final consumers and businesses. Energy distribution is a service industry as well as a goods-producing industry. Much of the value of gasoline at the pump and electricity or natural gas at the meter is provided by the process of getting those resources from a hole in the ground to the final consumer in a form that can be efficiently utilized. Much of this value is added within the Iowa economy.

Spending for petroleum product imports represent the largest dollar expenditure for energy in Iowa. In terms of percentage share of inputs, natural gas import expenditures represent the largest share of energy dollar being spent for imported energy. According to IMPLAN estimates, 52.4 percent of the total expenditures for natural gas leak out of the state. The percentage is higher for petroleum processing and distribution facilities in the state (78.5) because of the lack of any refining capacity in Iowa. If we include the margins for retailing and wholesaling, 41.6 percent of the total expenditure for petroleum products leaves the state. The leakage share is smallest for electricity because most of the generation occurs within Iowa, and the distribution functions all are within state. Our estimates indicate only 17.8 percent of the total electricity expenditures leak out of Iowa. Table 13 summarizes Iowa energy expenditures and leakages by energy type.

Table 13. Energy Leakages

	2001 Expenditure ($ billion)	**Leakage (percent)**	**$ Exported ($ million)**
Natural Gas	1.59	52.4	834.5
Petroleum	4.08	41.6	1697.3
Electricity	2.41	17.8	428.6
TOTAL	**8.08**	**36.6**	**2960.4**

Renewables, such as wind energy, ethanol, and biodiesel, have some potential to diminish these leakages, but this potential will require significant changes in distribution networks and consumption patterns to generate major inroads into Iowa's energy purchases. While the production of agriculturally derived fuels continues to increase, significant changes in fuel distribution and utilization will have to occur before this results in a fundamental change in Iowa's energy balance sheet.[15] Wind energy is also a growing source of Iowa's fuel. This is not to suggest that there is no value in alternative fuel activities, it is simply recognition of the reality of the energy production, distribution, and consumption networks that exist in Iowa and the United States, today.

Policy Implications

Many of Iowa's major economic sectors are intensive energy users. Agriculture production uses energy directly in grain production, drying, marketing and also indirectly through many of the purchased inputs such as fertilizer and agricultural chemicals. Many of the manufacturing industries, including agricultural processing, are also intensive energy users. These industries are very efficient in their production processes and are well established in Iowa for logistical reasons.

Because the major energy consumers and vendors in Iowa rely on out-state resources and refineries for primary energy supplies, the scope for substituting energy sources in Iowa is limited over the short term. Other than alternative electrical energy that directly enters the power grid, most alternative fuels available in Iowa do not provide perfect substitutes for energy sources currently utilized. This also limits substitution strategies in the short term.

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[15] Agriculturally derived fuels also have yet to prove themselves as economically viable energy sources in the absence of explicit input and production subsidies.

This does not mean that there is no potential for alternative and renewable fuels to offset current Iowa energy consumption. It does mean that current energy relationships have been established over time because they efficiently met the needs of energy consumers in the environments where they were developed. In the absence of a Field of Dreams ("If you build it, they will come") perspective, one must recognize and address the changes in production relationships, distribution systems, and utilization technology that will be required for an efficient large-scale migration to alternative fuel sources. Successful and sustainable change requires dealing effectively with current realities.

These factors are important in the context of this report. In estimating the flow of Iowa consumption dollars out of the state, the exploration of ways to keep these dollars in-state implicitly begins. There are three immediately recognizable strategies for to reducing Iowa's energy consumption expenditure outflow.

1. Increasing the proportion of expenditures from existing consumption that remain in state
2. Substituting in-state energy resources for current out-of-state fuels
3. Reducing energy consumption

The first of these is limited. There are two ways to increase the in-state expenditure share of current energy consumption. The first is to reduce the import price level of the energy sources, which is almost entirely out of Iowa consumers' control. The second is to increase the pricing component of services added to the energy as part of the in-state distribution process. The second, without the first, requires increased consumer prices, which are only justifiable if the additional services priced into the consumer energy product result in equivalent increases in value to the consumer. This is not expected to be the general case.

As mentioned, above, the ability to substitute in-state energy sources for out-of-state energy sources (strategy number 2) is limited in the short term by substitutability and established delivery systems. In-state alternative energy sources could include solar energy, wind turbines, ethanol, and non-ethanol bio-fuels to the extent that production technology and distribution systems make these alternatives economically viable. It is critically important that substitution be driven by efficiency as well as by locality. Utilizing local alternatives is not an economic benefit in instances where local alternatives are less efficient than out-of-state fuel sources. The economies of Iowa, the United States, and the world would look significantly different if local sourcing took precedence over efficiencies that are often available through trade.

Electricity from alternative sources (once it is in the power grid) is the only Iowa-produced alternative fuel that is a perfect substitute for its traditional alternative. Wind generated electricity is the largest component of this alternative. Wind power has improved its generating efficiency and has expanded rapidly in recent years. A relative concentration of wind generating capacity in Northwest Iowa and Southwest Minnesota suggests a possibility for developing in-state support services for wind turbine installation and maintenance. This would increase the in-state service component of this energy source. Increased wind energy generation could also provide opportunities to substitute away from imported electricity in the area or to recruit additional manufacturing facilities into the area that can utilize the energy produced. Alternatively, increased wind generation could result in a reduction of traditional electrical generation plant and investment in Iowa if consumption levels are held static.

While there is evidence that substantial quantities of wind-generated (or any other alternatively-generated) electricity can enter the grid without significantly affecting the operating costs of established generators in the short term, effective storage mechanisms will be needed to maintain an effective electrical production and distribution system utilizing wind generated electricity in the long term. This is a reflection of the facts that increased wind generation will reduce the expected returns from investment in other generation facilities and that increased wind generation in the absence of storage does not address peak load needs (one cannot always expect wind during peak load periods). Significantly increasing wind generation and lowering expected returns to investing in peak-load generation capacity without also addressing peak loads will inevitably increase the expectations of power shortages and brownouts during peak load periods.

Ethanol, the other major alternative fuel produced in Iowa, is not a perfect substitute for the petroleum products that it replaces. This does not automatically mean that ethanol is not a viable alternative, but it does mean that several issues are still to be worked out. In the current retail environment, ethanol fits best as a blended component on a relatively local distribution network. Blending minimizes differences in ethanol's energy content with petroleum gasoline. Limited geographic distribution networks minimize ethanol's shipping disadvantage relative to petroleum gasoline.[16]

In addition to substitutability issues, it is not yet clear that corn-based ethanol production in the upper Midwest is economically viable over the long term. Aside from general questions regarding the energy efficiency of the corn-ethanol production process, there are real issues of its relative viability in the face of ethanol produced in areas with warmer production environments, higher biomass capacities, and shorter distribution chains to large urban consumer areas. All of these issues must be addressed before locally produced ethanol becomes a viable alternative fuel on a major scale.

Similar examples could be found for other bio-based alternative fuels. Other regions of the country with higher number of growing degree days, the southeastern states in particular, would have a comparative advantage over Iowa in producing these fuels.

Energy efficiency is another possible strategy for reducing the leakage of energy dollars. A goal of 10 percent reduction in energy expenditures statewide would mean about a $800 million of additional dollars in consumer pockets and about $380 million fewer energy dollars leaving the state. This, of course, could be the result of declining energy prices or declining utilization, and increasing prices might result in increased expenditures even in the face of utilization declines. The fact remains, however, that with any given price structure, decreased utilization will result in decreased expenditures.

Decreased utilization can be accomplished in two ways. First, energy consuming activities can be curtailed. While this reduces utilization and expenditure, it comes at the cost of foregoing goods and services that clearly have some value. The alternative is to find more efficient processes to

[16] There are a number of shipping issues regarding ethanol relative to petroleum. First, the distributed small-lot production geography of ethanol makes it geographically unsuited to dedicated pipelines. In addition, its water affinity and refining incompatibility with petroleum products prevents its consolidation and transport on shared-use pipeline systems. A brief review of a variety of pipeline, rail, and truck tariffs suggests that pipeline transport costs about 0.01 cents per gallon per mile, rail transport costs about 0.05 cents per gallon per mile, and truck transport costs about 0.15 cents per mile per gallon. This shipping differential can be expected to limit the geographic distribution of ethanol in the absence of price premiums or production advantages. Also, in many areas where ethanol production is expanding that expansion may jeopardize local rail transport. Where rail service depends upon grain shipments, conversion of grain to ethanol may make rail service nonviable. This would result in increased costs and fuel components for all local goods and transactions that depend upon rail service, and would place further geographic limits on ethanol distribution.

reduce energy utilization while maintaining output and consumption. In the second case, the processes that lead to efficiency must cost less than the energy savings obtained or, inevitably, a reduction in output or consumption must make up the difference. To the extent that efficiencies or reductions can be obtained, issues of expenditure and leakage will become less critical.

None of this constitutes an argument that alternative fuels will not be viable alternatives in many areas of the economy over the long term. It is simply recognition of the realities of current power consumption and power consuming investments. While primary fuels from out-of-state sources are a major input of Iowa's energy sector in the short term, there is a wide range of other inputs used in delivering energy products to final consumers. Substantial portions of these inputs are produced in-state, and in some of these service sectors there may be opportunities for capturing more of these energy delivery expenditures within state.   Over the longer term, there is clearly increased potential for alternative energy products, from both in-state and out-of-state sources, to penetrate the Iowa energy market. The extent to which this changes the levels of Iowa energy expenditure leakage will depend upon how the relevant issues are resolved.

In the final analysis, all geographic areas specialize around the resources at hand. Areas with major petroleum or coal reserves would generally have trouble finding overall efficiency in supplying all necessary food locally. Iowa will most likely never produce the majority of its own energy. Energy efficiency is an important component of Iowa's industrial efficiency. Developing efficient energy alternatives is a valuable step towards energy efficiency in the long term. It is important, however, that efficiency rather than locality drive energy alternatives.

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Appendix 1. A Brief Discussion of I-O Modeling

An I-O model is essentially a generalized accounting system of a regional economy that tracks the purchases and sales of commodities between industries, businesses, and final consumers. Successive rounds of transactions stemming from the initial economic stimulus (such as a new plant or community business) are summed to provide an estimate of direct, indirect, induced (or consumer-related) and total effects of the event. The impacts are calculated for us using the IMPLAN Input Output modeling system, originally developed by the US Forest system and currently maintained by the Minnesota IMPLAN Group (http://www.implan.com/index.html). This modeling system is widely used by regional scientists in the U.S. and worldwide to estimate economic impacts.

I-O models are capable of providing many types of reports on regional data and interactions among sectors. For economic studies, several of the more important indicators are:1) total output, 2) personal income, 3) value added, and 4) jobs. Total output for most industries is simply gross sales. For public institutions we normally include all public and private spending, all direct sales and subsidies received in order to isolate the economic value of their output. Personal income includes the wages and salaries of employees, along with normal proprietor profits. Value added is another appropriate measure of economic effects. Value added is analogous to gross regional product. It includes all personal income, plus estimates of returns to investors, and indirect business taxes paid to state and local governments. In short, value added gives us a measure of the income or wealth that accrues to individuals and governments as a result of industrial activity in an area. Jobs, the fourth measure, represent the number of positions in the economy, not the number of employed persons.

We can also get detailed breakdown of this data into direct, indirect, induced, and total economic effects. *Direct effects* in this case refer to the set of expenditures made by businesses or consumers (Tables 2 and Tables 3, above). *Indirect effects* measure the value of supplies and services that are provided to the businesses providing products and services to snow mobile owners. *Induced effects* accrue when workers in the direct and indirect industries spend their earnings on goods and services in the region. Induced effects are also often called household effects. *Total effects* are the sum of direct, indirect, and induced effects. They are the total of transactions attributable to the direct activity that we are measuring.

The term *multiplier* is also often used when referring to economic effects or economic impacts. A multiplier is simply the total effects divided by the direct effects. It tells how much the overall economy changes per unit change in the direct effects (a dollar of output, a dollar of personal income, a dollar of value added, or a job). Multipliers help us to anticipate the potential change in the regional economy attributable to a change in direct activity in a particular industry. Firms with strong linkages to area supplying firms or that pay relatively high earnings may yield high multipliers. Firms that are otherwise not connected strongly locally or that pay lower than average wages will have lower multipliers. Urban areas with their more developed economies have, on the average, much higher multipliers than rural areas.