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CALIFORNIA ENERGY FLOW IN 1980

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Abstract

Energy consumption fell slightly in California during 1980. In view of an increase in population on the order of 375,000 the per capita consumption fell even more, but less than 4%.

Transmitted electric power remained near 1979 levels, but oil as a electrical generating fuel declined dramatically (40%). In its stead natural gas and hydropower were used to generate electricity. Mild winters in 1979-80 and 1980-81 made unusual amounts of natural gas available for that purpose. Both California and out-of-state sources of hydropower increased during 1980. Electricity from out-of-state coal fired plants also increased slightly. Problems at San Onofre nuclear plant resulted in a 47% decrease in electricity from one of the two commercial nuclear plants operating in California in 1980.

Decreased oil use also had a clear expression in the transportation end use sector. Gasoline consumption dropped 4% as it had in 1979 as well. Sales of vessel bunkering fuels increased as part of a trend related to larger amounts of heavy oils from local and Alaskan sources being refined in the state and decreased use of lighter Indonesian oils.

Residential/commercial usage dropped 5% during 1980 as a consequence of price driven conservation and mild weather. By contrast, the industrial sector increased its energy consumption by 6%.

California's overall energy use pattern continues to differ substantially from that of the U.S. as a whole. The dedication of large amounts of fossil fuels to transportation, the total absence of

coal-fired plants for power production in the state and the larger share of oil and natural gas used for electrical power generation are among California's energy situation's distinguishing features. In 1980, combined use of oil and gas declined for the first time in some years by 4%. The national average decline for 1980 was 7%.

INTRODUCTION

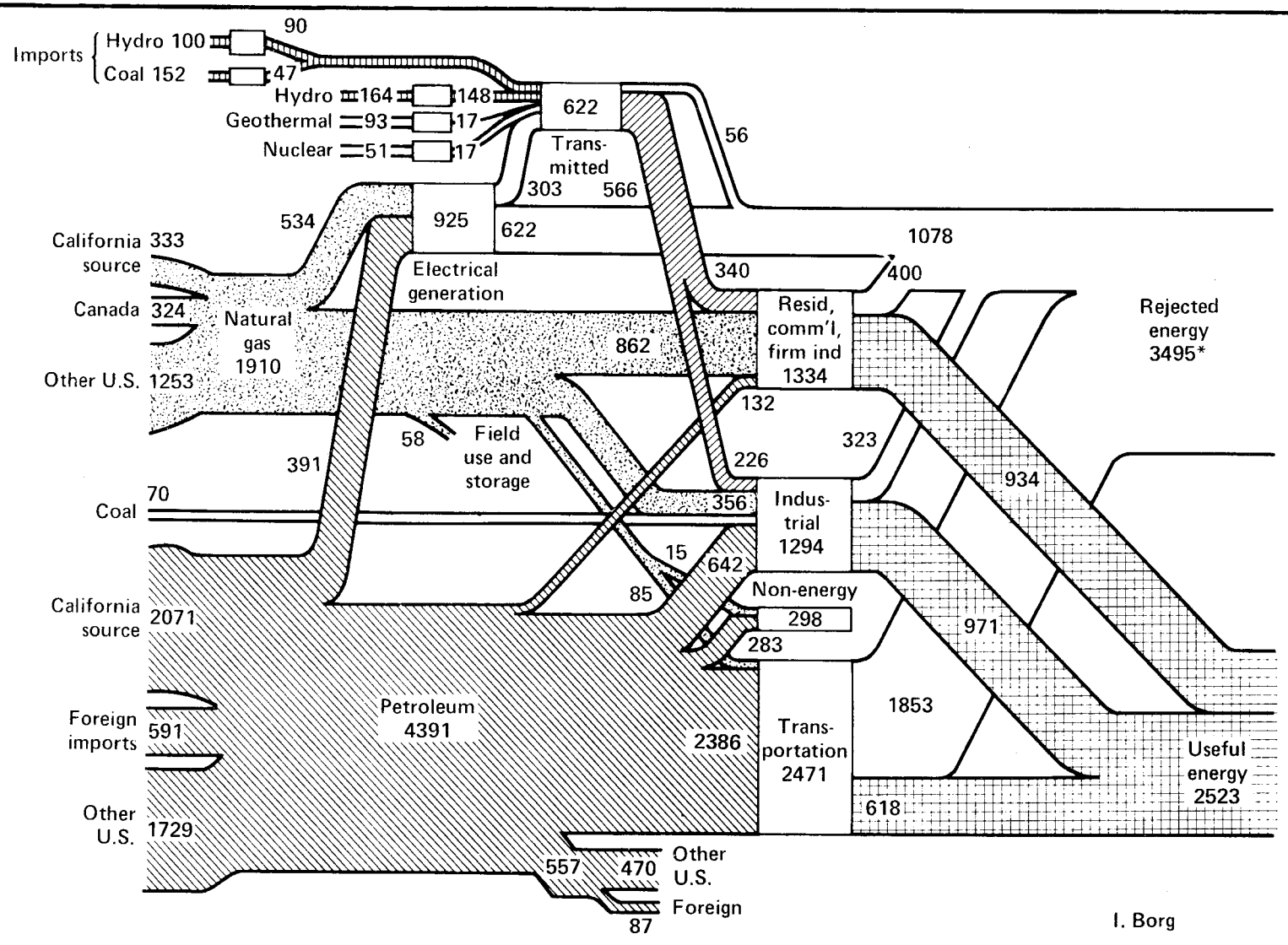
Energy flow diagrams for California prepared for 1974, 1976, 1977, 1978, and 1979 by members of Energy and Resource Planning Group at the Lawrence Livermore National Laboratory have proven to be useful tools in assessing supply and end use of energy in the state.[1-5] To assure uniformity with other years as far as possible, the same sources and conventions were used for the 1980 California energy flow diagram presented here. (Figure 1).

To this end we have also used the same conversion efficiencies as used in construction of past energy flow diagrams. For conversions to electrical power they are assumed to be 90% (hydro-electricity), 30% (coal), 18% (geothermal), 33% (oil and gas) and 32% (nuclear). Assumed efficiency for transportation is 25% which is the approximate efficiency of the internal combustion engine. As in past years 70% and 75% were arbitrarily assumed in residential/commercial and industrial end use sectors respectively. See Ref. 2 for a more detailed description of how major end use sector efficiencies were determined.

Source of Data

Tables 1 and 2 list the supply and end use sources. Most of the data were compiled from the California Energy Commission (CEC) Quarterly Fuel and Energy Summaries. The 66th Annual Report of the State Oil and Gas Supervisor provided crude oil and natural gas production figures (347 million barrels of oil and 311 BCF of gas) including production from federal offshore fields (10 million barrels and 6 BCF).

CALIFORNIA ENERGY FLOW – 1980
TOTAL ENERGY CONSUMPTION 6400 × 10^{12} Btu



*Includes rejected energy from hydro, coal, geothermal and nuclear conversions

Data: California Energy Commission; California Division of Oil & Gas, DOE/EIA

Figure 1

Table 1

Data Sources for California Energy Supply (1980)

Production	
Crude Oil including Federal Offshore and Lease Condensate	Ref. 6
Associated and Nonassociated Natural Gas	Ref. 6
Electrical Generation (hydro, coal, nuclear, oil, gas, geothermal)	Ref. 7, Tables A, B, & C
Imports	
Natural Gas Foreign and Domestic	Ref. 7, Table A
Crude Oil Foreign and Domestic	Ref. 7, Table I
Oil Products Foreign and Domestic	Ref. 7, Table M
Coal	Ref. 8, Table 10
Electrical Power	Ref. 7, Table A
Exports	
Oil Products Foreign and Domestic (not including bunkering fuels supplied at California ports)	Ref. 7, Table N

Table 2

Data Sources for California End Uses (1980)

Net Storage and Field Use	
Natural Gas	Ref. 7, Tables A & F
Transportation	
Crude Oil	
Refinery output of gasoline, aviation fuel and jet fuels	Ref. 7, Table K
Taxable diesel fuel (i.e. for public highways)	Ref. 9
Vessel Bunkering (includes international bunkering)	Ref. 10, Table 8
Exports of gasoline, jet fuel	Ref. 7, Table N
Rail diesel	Ref. 10, Table 8
Military Use	Ref. 10, Table 9
Natural Gas	
Lost or unaccounted for from gas utilities (transmission and pipeline)	Ref. 7, Table D
Industrial, Government, Agriculture, etc.	
Natural gas	by difference
Coal	
Ref. 8, Table 10	
Electricity	Ref. 7, Table C
Crude Oil	by difference

Data Sources for California End Uses (1980) Cont'd

Non Energy Applications	
Crude Oil and LPG	
Asphalt	Ref. 11, Table 2
Petrochemical feedstock	Ref. 7, Table K
Waxes, lubricating oils, medicinal uses, cleaning	1/3 of asphalt & road oil totals Ref. 4
Natural Gas	
Fertilizer	Estimated from 1979
Residential and Small Commercial	
Natural Gas	Ref. 7, Table D
Crude Oil and Other Oils (heating) Kerosene, Residual and Distillate	Ref. 10, Tables 4 & 5
LPG	Ref. 7, Table E
Miscellaneous "off highway" diesel	Ref. 10, Table 11
Electricity	Ref. 7, Table B

AGGREGATION OF DATA

As in past years the flow diagram combines residential, commercial and firm industrial customers, all with highest priority among utility customers. Interruptible industrial customers make up another large end use sector. The category called "Non-energy" use includes petrochemicals, asphalt, waxes, fertilizer etc.; these uses produce neither heat nor mechanical work.

Out-of-state hydro-electric power is from the Pacific Northwest (Bonneville Power Administration) and the Southwest (principally Hoover and Davis Dams on the Colorado River). The transmitted electrical power from imported hydro sources was derived from the net exchange in interstate transfers; power from out-of-state coal-fired plants is recorded separately by the CEC.

Out-of-state coal fired plants are at Four Corners, Farmington, New Mexico; the Navaho Plant at Page, Arizona; and the Mohave Plant, Nevada.

Conversion from fuel quantities to Btu was made using U.S. Bureau of Mines factors given in the Appendix.

COMPARISON WITH 1979 AND PAST YEARS

Table 3 (tabulated in part from Fig. 1 and Fig. 2) provides a quick comparison of energy consumption in the 1976-1980 period. 1980 was considerably warmer than the "normal" (Table 4) especially in the Southern part of the state. Electric utilities (lowest priority user -- Priority 5) burned 17% more natural gas to produce electricity than in 1979, following a pattern initiated in 1979 when use for electrical generation increased 47%.

Table 3

Comparison of Annual Energy Use in California

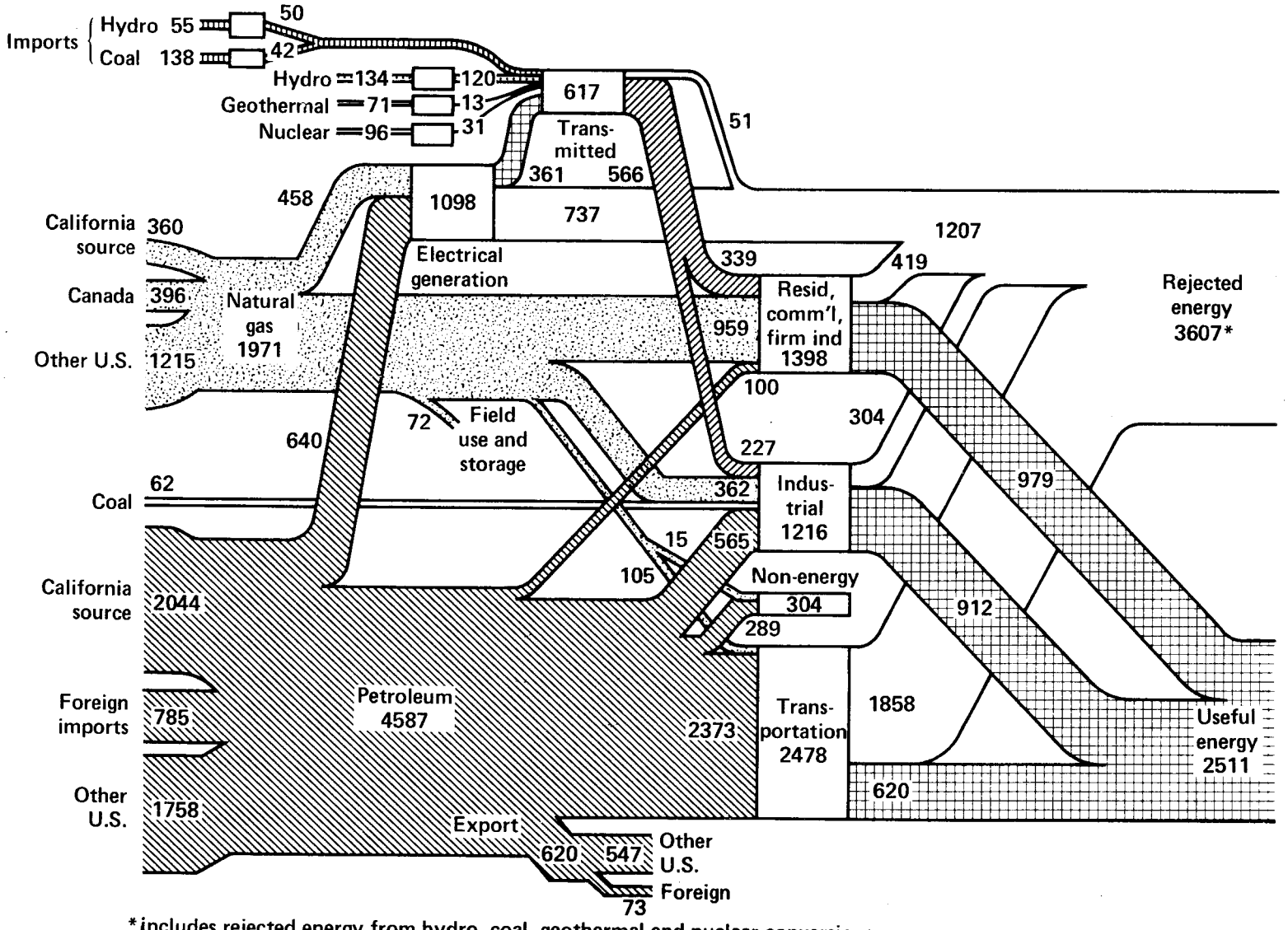
(in 10^{12} Btu)

	1976	1977	1978	1979	1980	% Change 1979 vs 1980
1980						
Natural Gas	1844	1831	1724	1971	1910	-3.1
Crude Oil	3886	4516	4379	4587	4391	-4.3
California Source	1921	2027	2014	2044	2071	+1.3
Foreign Imports	1606	1875	940	785	591	-24.7
Other U.S.	359	614	1425	1758	1729	-1.6
Domestic/Foreign Exports	630	796	598	620	557	-10.2
Net Use	3256	3720	3781	3967	3834	-3.4
Electricity						
Imports*	158	100	121	92	137	+48.9
Imports**	267	208	203	193	252	+30.6
Hydroelectric	94	54	144	134	164	+22.4
Geothermal and Other	79	63	54	71	93	+31.0
Nuclear	51	84	81	96	51	-46.9
Gas	358	380	312	458	534	+16.6
Oil	619	806	619	640	391	-38.9
Total Fuel	1413	1595	1413	1592	1485	- 6.7
Total Transmitted Energy	577	574	597	617	622	+ 1.0
Residentail/commercial/firm industrial	1406	1253	1321	1398	1334	- 4.6
Industrial	1162	1248	1088	1216	1294	+ 6.4
Nonenergy	222	221	239	304	298	- 2.0
Transportation	2004	2199	2438	2478	2471	- 0.3

* As imported Mw•h (not energy-fuel equivalents)

** As hydroelectric power or coal before conversion to electricity

CALIFORNIA ENERGY FLOW – 1979
TOTAL ENERGY CONSUMPTION 6500 X 10^{12} Btu



*includes rejected energy from hydro, coal, geothermal and nuclear conversions.

Data: California Energy Commission; California Division of Oil & Gas, DOE/EIA.

Figure 2

Table 4

WEATHER COMPARISON

1958-1980

ANNUAL HEATING DEGREE DAYS*

	San Francisco Federal Office Building	Los Angeles Civic Center	San Diego Lindbergh Field
1958	2332	849	805
1967	2978	1040	1380
1968	2942	850	1052
1969	3066	1032	1145
1970	3006	941	1137
1971	3468	1424	1657
1972	3240	918	1166
1973	3161	1066	1137
1974	3182	1084	1123
1975	3313	1548	1416
1976	2665	1128	793
1977	2888	911	747
1978	2599	1208	736
1979	2545	1160	902
1980	2799	597	590
Normal			
1941-70	3080	1245	1507

*Source: Local Climatological Data, for San Francisco, Los Angeles, and San Diego.

National Oceanic and Atmospheric Administration
National Climatic Center
Asheville, N.C.

The increase reflects the enactment of the Natural Gas Policy Act of 1978 which eliminated the two-tier price structure between interstate and intrastate gas. Higher prices brought more gas to California from former intrastate producers. In addition the comparative warm winters of 1979-80 and 1980-81 resulted in low demand in the residential and commercial sectors during peak periods thereby freeing natural gas for electrical generation. This also resulted in a dramatic decrease in use of oil for power production - down 39%. Hydropower dedicated in other states and imported as electrical energy and hydropower generated within the state contributed substantially more to electrical power resources than in 1979. Installed geothermal capacity continued to climb. Geothermal power contributed 2-3% to electrical demand in California.

California had two nuclear plants in commercial operation - Rancho Seco (913 MWe) near Sacramento and San Onofre 1 (436 MWe) at San Clemente. San Onofre 2 (436 MWe) and 3 (1100 MWe) were 92 and 63% respectively complete in 1980. Power from the two operating plants was down 47% in 1980. Refueling and maintenance outage in April at San Onofre was protracted by discovery of steam generator tube corrosion.[12] The reactor was out until December for repairs. Pacific Gas and Electric Co's Diablo Canyon continued to await licensing in 1980.

The sources of natural gas for the Northern part of the state serviced by Pacific Gas & Electric Co. are shown in Table 5. Also included are prices associated with the three principal sources over time. Canadian prices in 1980 were on parity, or near parity, with oil and have influenced gas prices from other sources as well under

Table 5

Source, Shares and Prices of Natural Gas

to Pacific Gas & Electric Co. at the

California Border (Prices: $/1000 cu. ft.)

	Weighted	Canada		SW U.S.		California	
Year	Price	Price	Share	Price	Share	Price	Share
1981	3.35_1	5.07_4	(30.9%)	2.57_3	(49.5%)	2.59_8	(19.6%)
1980	3.17_3	4.56_3	(39.7%)	2.29_9	(44.1%)	2.15_9	(16.2%)
1979	2.23_4	2.79	(45.3%)	1.79_1	(37.6%)	1.73_6	(17.1%)
1978	1.89_3	2.40_2	(47.7%)	35_4	(35.6%)	1.59_4	(16.7%)
1977	1.60_7	2.18	(46.6)	1.10	(37.0%)	112.1	(16.4)
1976	1.34_3	1.92_1	(45%)	0.83	(38.2%)	0.96_1	(16.8%)
1975	$.97_3$	1.36_8	(42.4%)	$.72_7$	(41.4%)	$.56_7$	(16.2%)
1974	$.57_4$	$.65_4$	(39.5%)	$.55_8$	(43.7%)	$.42_7$	(16.8%)
1973	$.42_0$	.44.1	(38.0%)	$.43_0$	(38.4%)	$.37_0$	(23.6%)
1972	$.37_2$	$.36_9$	(36.2%)	$.39_4$	40.3%	$.33_7$	(23.5%)
1971	.344	$.32_7$	(34.0%)	$.37_5$	(41.2%)	$.31_7$	(24.8%)
1970	$.31_9$	$.30_4$	(31.1%)	$.33_9$	(43.7)	30.2	(25.2%)

Source: PG&E Annual Reports

phased deregulation allowed under the Natural Gas Policy Act of 1978. The weighted average in 1980 was $3.17, per 1000 cu. feet. The ceiling under deregulation would probably be set by parity with $32 per barrel oil or at approximately $5.07 per 1000 cubic feet.

Alaskan North Slope crude oil supply stayed at 1979 levels. The maximum production at the Prudhoe Bay field allowed by the State of Alaska (1.5 million barrels per day) was reached in April, 1980. Foreign imports, primarily from Indonesia, which is the largest single source at approximately 76 million barrels, decreased by 25%. This followed a 17% decrease in 1979 over 1978. Since Alaskan crude oil is lower gravity and higher in sulfur content than foreign oil, California refinery output of high sulfur residual oil increased and produced a surplus of this product. Refiners reduced the price of high sulfur residual oil which attracted ships to refuel in California. Hence, Bunker C fuel sales increased 20% in 1980 over 1979.

Residential/commercial and firm industrial usage decreased 5% from 1979. Mild winter weather contributed to the drop as evidenced by the large influence decreased natural gas use had on the total. Price driven conservation almost certainly also contributed to the drop in these end-use sectors (Table 5). In matter of fact on a per capita basis usage dropped by a larger percent since the state's population is estimated to have increased 375,000 during 1980 to 23,260,000.[13]

Industrial sector end use increased 6%. Use of petroleum increased 11% whereas coal, natural gas and electrical input to the industrial sector were approximately the same as the previous year.

Transportation sector total usage showed a small decrease over the past year. (See Table 6). A decrease in the amount of gasoline use (4%) was more than compensated for by increased sales of Bunker C fuel (20%). Much of the bunkering fuels sold in California are used in international traffic. Since a break-down between coastal and

Table 6

Transportation End Use

	x 10^{12} BTU		
	1978	1979	1980
Net Gasoline	1500	1439	1375
Net Aviation Fuel	357	350	346
Taxable diesel fuel-Public Highway	149	161	160
Rail diesel	35	35	43
Net Bunkering	288	358	430
Military	30	30	32
Total	2359	2373	2386

international traffic is not available, it is included as part of the state transportation picture. Limited amounts of Bunker C oils are also included in the exports (and imports) shown in Figures 1 and 2. These oils are exported for various uses on land - e.g. boiler fuel in Pacific Islands or storage for fishing fleets. The quantities of Bunker C included in the export category are small compared to the amounts sold for vessel bunkering at California ports.

A drop in the use of aviation fuels reflects in part the Pacific Southwest Airline strike September 26 through November 7, 1980.

COMPARISON WITH U.S. ENERGY USE

California's energy mix and consumption patterns continue to be in marked contrast to the nation's. A comparison of Figure 1 and 3 from Rf. 14 shows the greater role oil and gas have in energy production in California than in the U.S. In 1980 combined oil and gas use fell 4% in California. In the U.S. in 1980 by contrast it fell 7%. Coal continues to play a very minor role in the industrial sectors in California. There are no coal burning electrical power plants within the confines of the state. The importance of oil and gas is a reflection on the indigenous industry and the availability of supplemental supplies from Western states. The principal use of oil in California is in the transportation sector. For this reason light oils imported from Indonesia are used in preference to an exclusively California/Alaska mix. The latter have a relatively smaller gasoline/light product output from conventional refinery distillation operations than do lighter oils with API gravities greater than $^{o}30$. The higher sulfur content of most heavy oils also mitigates against their use in California's polluted air basins. Fuel oil is used sparingly in California for residential and commercial space heating. In the U.S. as a whole about one quarter of all oil consumed goes to the residential/commercial sector.

U.S. ENERGY FLOW – 1980
(NET PRIMARY RESOURCE CONSUMPTION 75 QUADS)

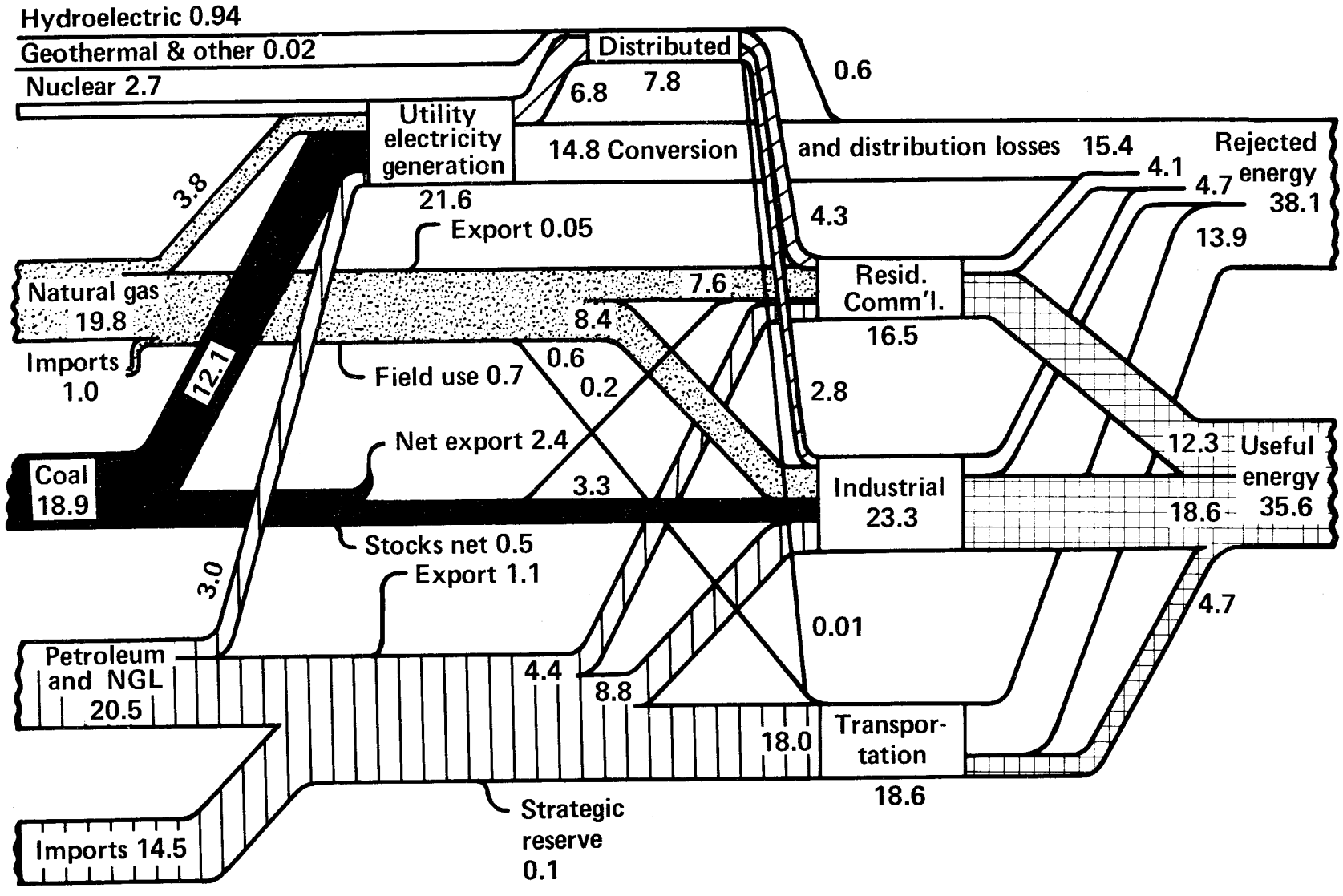


Figure 3

APPENDIX: CONVERSION UNITS

Energy Source	Conversion factor, 10^6 Btu
Electricity	3.415 per MW.h
Coal	22.6 per short ton
Natural Gas	1.05 per MCF
LPG	4.01 per barrel
Crude Oil	5.80 per barrel
Fuel Oil	
Residual	6.287 per barrel
Distillate, including diesel	5.825 per barrel
Gasoline and Aviation Fuel	5.248 per barrel
Kerosene	5.67 per barrel
Asphalt	6.636 per barrel
Road Oil	6.626 per barrel
Synthetic Rubber and Miscellaneous	
LPG Products	4.01 per barrel

REFERENCES

1. E. Behrin and R. Cooper, California Energy Outlook, Lawrence Livermore Laboratory Rept. UCRL-51966, Rev. 1 (1976).

2. I. Y. Borg, California Energy Flow in 1976, Lawrence Livermore Laboratory Rept. UCRL-52451 (1978).

3. I. Y. Borg, California Energy Flow in 1977, Lawrence Livermore Laboratory Rept. UCID-18221 (1979).

4. C. Briggs and I. Y. Borg, California Energy Flow in 1978, Lawrence Livermore Laboratory Rept. UCID-18760 (1980).

5. C. Briggs and I. Y. Borg, California Energy Flow in 1979, Lawrence Livermore National Laboratory Rept. UCID-18991 (1981).

6. 66th Annual Report of the State Oil and Gas Supervisor, California Division of Oil and Gas, Rept. No. Pro 6 (1980).

7. Quarterly Fuel and Energy Summary; Fourth Quarter 1980, California Energy Commission, Sacramento, CA.

8. Coal Distribution, January-December, 1980. Energy Data Report DOE/EIA-0125 (80/4Q) (April 7, 1981).

9. California Statistical Abstracts, State of California, Sacramento, CA (1981).

10. Delivery of Fuel Oil and Kerosene in 1980 DOE/EIA-0113 (80).

11. Sales of Asphalt in 1980, Energy Data Report DOE/EIA-0112 (80), June 8, 1981.

12. Nuclear News (September 1980) p. 32.

13. Annual Energy Production & Consumption, 1980 California Energy Commission, Sacramento, CA (September, 1981).

14. C. Briggs & I. Y. Borg, U.S. Energy Flow - 1980, Lawrence Livermore Laboratory Report UCID-19227-80, (October 21, 1981).

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