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CALIFORNIA ENERGY FLOW IN 1989

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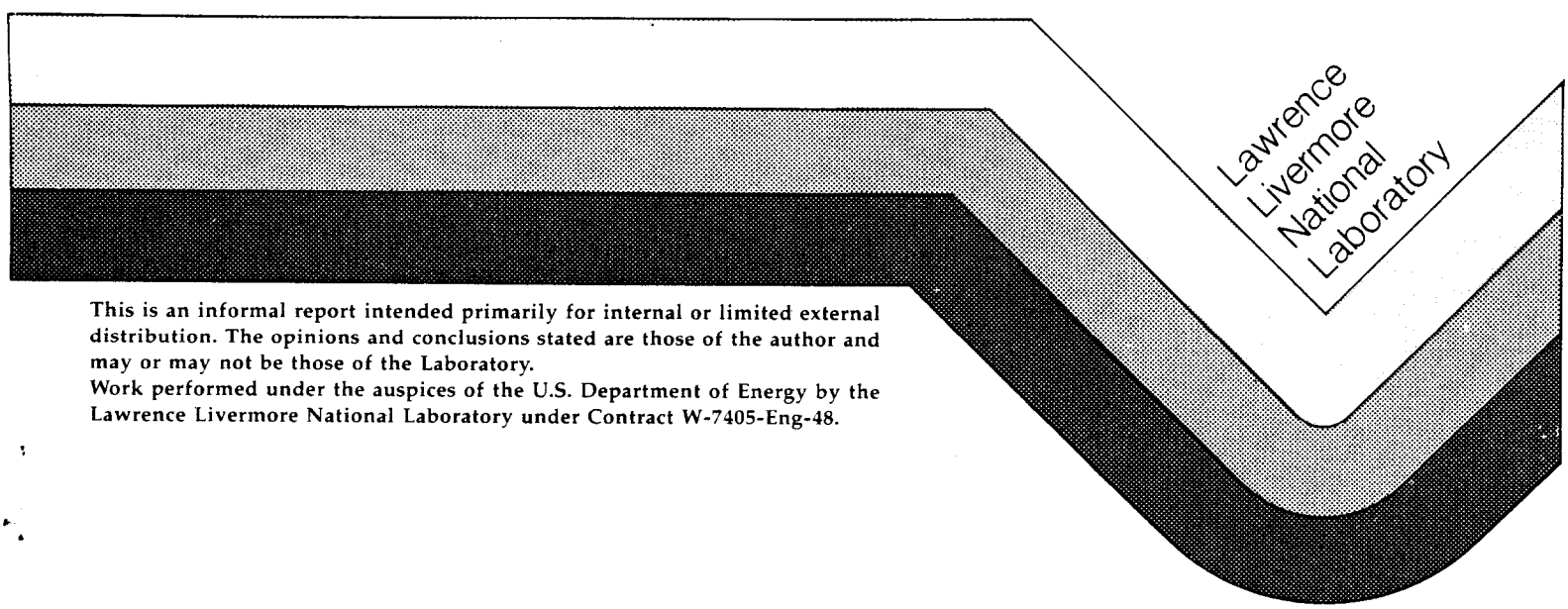

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ABSTRACT

California's energy use showed a modest increase (2.2%) in 1989 over 1988 which was in keeping with the steady increase in population that the state has experienced annually during the decade. All end-use sectors (residential, commercial, industrial, transportation, etc.) contributed to the growth. The larger demand was met by increased imports of all major fuels. Only electrical imports remained close to 1988 levels, in part due to increased output from Diablo Canyon nuclear plant whose performance exceeded expectations. California's per capita energy consumption has traditionally been below the national average due to the relatively benign climate associated with its centers of population.

The largest single use for energy in the state was for transportation which overtook industrial usage in the 60's. Use of highway fuels continued to grow and reached all time highs in 1989. Highway congestion, a major problem and concern in the state, is anticipated to grow as the number of licensed drivers increases; in 1989 the increase was 3.4%.

Output from the The Geysers Geothermal fields, the largest in the world, continued to falter as the steam output fell. Nonetheless new resources at the Coso Geothermal Resource Area and at the Wendel Geothermal field came on line during the year, and other geothermal areas were under active development. Novel sources of renewable energy (solar, wind, etc.) grew; however, collectively they made only a small contribution to the overall energy supply. Cogenerated electricity sold to the utilities by small power producers inexplicably fell in 1989 although estimates of the total capacity available rose.

INTRODUCTION

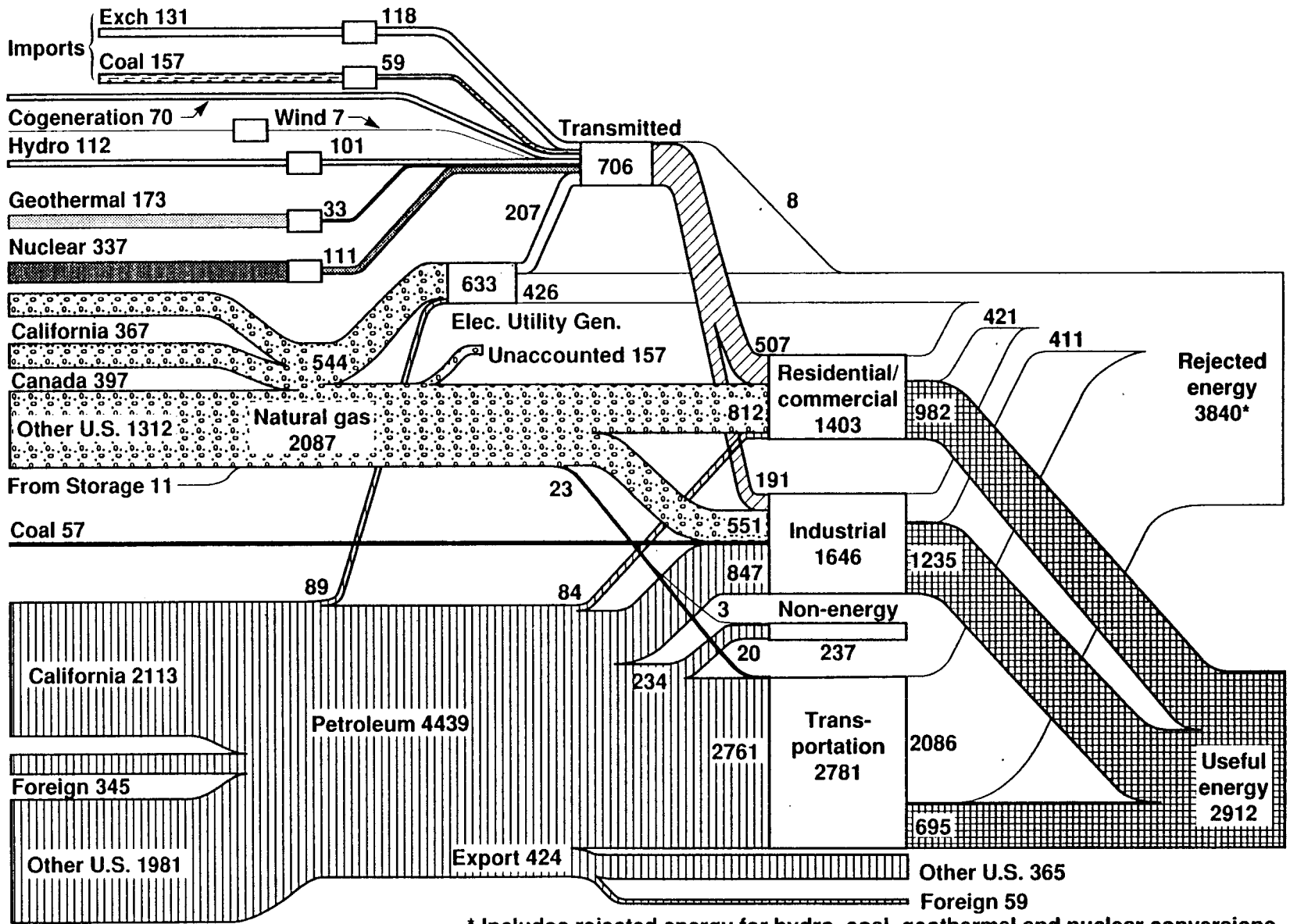
For the past ten years energy flow diagrams for the State of California have been prepared from available data by members of the Lawrence Livermore National Laboratory.[1-6] They have proven to be useful tools in graphically expressing energy supply and use in the State as well as illustrating the difference between particular years and between the State and the U. S. as a whole.

As far as is possible, similar data sources have been used to prepare the diagrams from year to year and identical assumptions[1,2,3] concerning conversion efficiencies have been made in order to minimize inconsistencies in the data and analyses. Sources of data used in this report are given in Appendix B and C; unavoidably the sources used over the 1976-1989 period have varied as some data bases are no longer available. In addition, we continue to see differences in specific data reported by different agencies for a given year. In particular, reported data on supply and usage in industrial/commercial/residential end-use categories have shown variability amongst the data gathering agencies, which bars detailed comparisons from year to year. Nonetheless, taken overall, valid generalizations can be made concerning gross trends and changes.

CALIFORNIA ENERGY FLOW DIAGRAMS

Energy flow diagrams for 1989 and 1988 are shown in Figures 1 and 2 respectively. Energy sources are shown on the left and energy consumption is shown on the right. The energy balance between the two is given in Appendix A. Also shown on the right are estimates of conversion efficiencies in the end-use sector, which result in a division between useful and rejected energy. The latter consists primarily of heat losses but also includes other sorts of losses such as line losses during electrical transmission. Inputs to total transmitted electricity such as nuclear, geothermal power, etc., are associated with estimated efficiencies of the conversion process to electricity. They vary from 90% in the case of hydroelectric power to 18% for geothermal energy.

CALIFORNIA ENERGY FLOW - 1989
TOTAL CONSUMPTION 6900 $\times 10^{12}$ Btu



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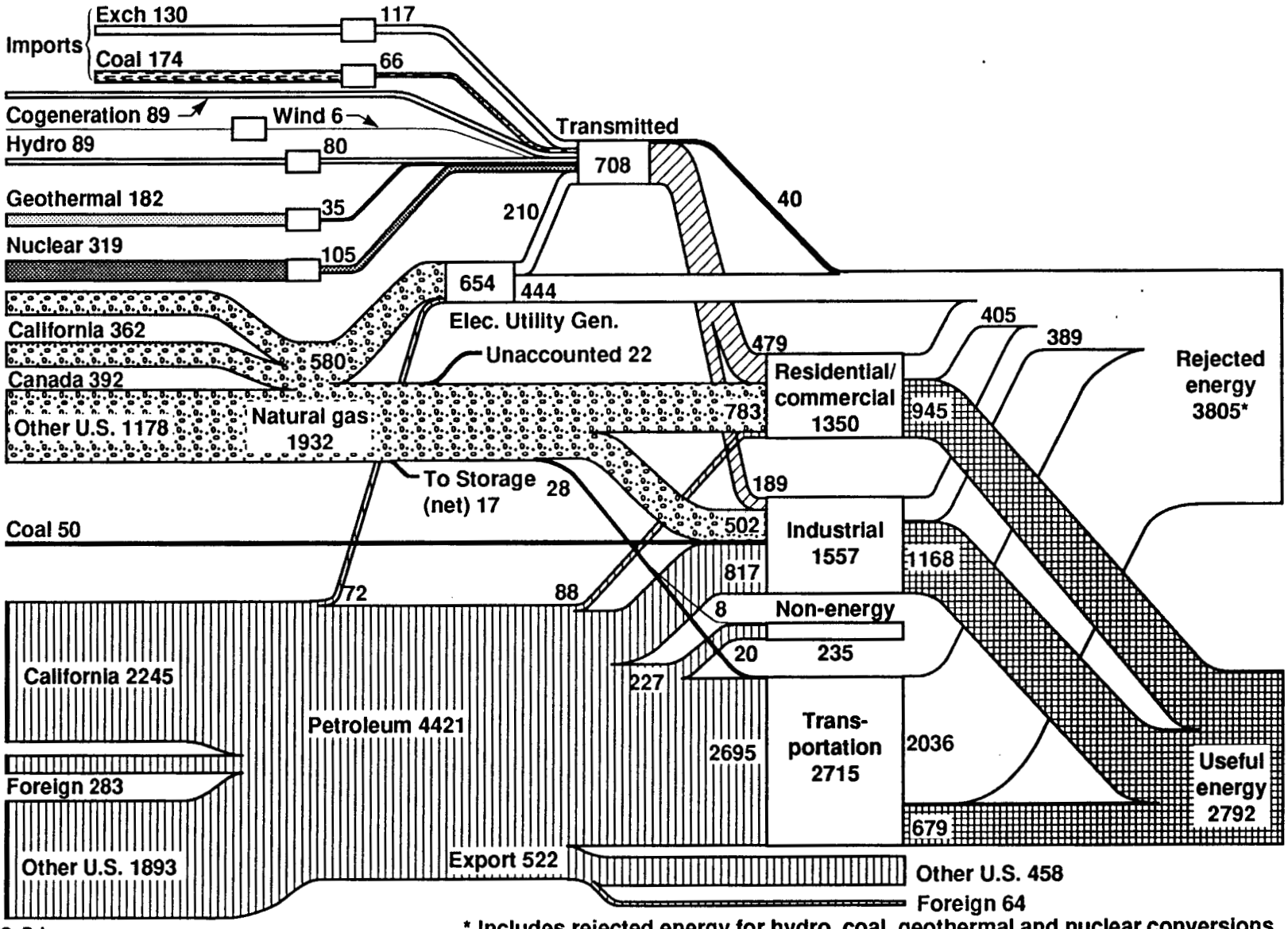
* Includes rejected energy for hydro, coal, geothermal and nuclear conversions

Figure 1

CALIFORNIA ENERGY FLOW - 1988
TOTAL CONSUMPTION 6750 $\times 10^{12}$ Btu



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

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Figure 2

Assumptions concerning the conversion efficiencies are given in Appendix D and their rationale can be found in Ref. 2 and 3. The box separating the energy source from the final electrical output represents the conversion process. In all cases, the quantities associated with the energy source are calculated based on assumed conversion efficiencies. While it is desirable to minimize the number of assumptions in preparing an energy flow diagram, it is also desirable to express as closely as possible the energy content of the sources used during the year. In this way, changes and improvements in overall fuel conversions that occur over the course of time by virtue of fuel switching and use of renewable sources such as windpower or solar energy have an expression in the total energy consumption in the state.

Power from cogenerators and self-generators shown in the figures as inputs to total transmitted electricity appear without a box (representing the conversion process) that ordinarily would appear between the energy content of the fuel and the final product. In this instance, conversion losses are included in "rejected energy" from the industrial sector.

CALIFORNIA'S ENERGY FLOW IN 1989 COMPARED TO 1988

California's energy use increased modestly in 1989 (Table 1) as might be expected from the steady population increase the state has experienced during the decade. Judging from the heating degree days tallied at major monitoring stations (Table 2), heating requirements in the major population centers in the southern part of the state were near those of 1988. The northern sectors were somewhat cooler; however the state as a whole was below 1961-1987 averages.

Almost all end-use sectors - residential, commercial, industrial, transportation, etc. contributed to the increase in energy use. The additional fuel requirements were met by increased imports of natural gas and crude oil. Only electrical imports dropped slightly because of the increased output of hydroelectric and nuclear plants in the state. Total electrical usage remained close to 1988 levels.

California's energy consumption on a per capita basis is approximately 78% of the U. S. average.[7] This is in part a reflection on the location of the State's population centers in temperate climate zones. Both Florida and Hawaii are associated with even less per capita energy consumption. The states that exceed U. S. averages on a per capita basis tend to be associated with climatic extremes, e. g. Alaska, Wyoming, North Dakota, Louisiana and Texas.

Table 1

Comparison of Annual Energy Use in California

(in 10^{12} Btu)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Natural Gas	1971	1910	2010	1893	1769	1865	2034	1697	2091	1932	2087
Crude Oil (less exports)	3967	3834	3650	3327	3329	3477	3580	3601	3591	3899	4015
Transmitted Electricity	617	622	620	642	622	700	673	697	718	708	706
Residential/Commercial	1398	1334	1370	1225	1268	1176	1325	1224	1325	1350	1403
Industrial 1088	1216	1294	1400	1570	1395	1493	1648	1456	1439	1557	1646
Non-energy	304	298	165	158	183	221	185	203	292	235	237
Transportation	2478	2471	2430	2265	2313	2464	2384	2499	2564	2715	2781
Total Energy Consumption†	6500	6400	6300	6000	5900	6200	6400	6200	6600	6750	6900

† Total is not sum of above figures because of rounding and inclusion of losses associated with conversion to electrical energy.

Table 2
Weather Comparison
1958 - 1989
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
1981	2819	506	573
1982	3195	975	913
1983	2386	602	623
1984	2648*	704	713
1985	2486*	921	1079
1986	1842*	473	843
1987	2150*	979	1201
1988	2194*	867	1102
1989	2526*	844	1068
Normal 1961-87	2756***	1204	1284

* CA. Mission Dolores - same historical data as for Federal Office Building
Source: Local Climatological Data for San Francisco, Los Angeles and San Diego, National Oceanic and Atmospheric Admin., National Climatic Data, Asheville, N.C.

** A "degree day" is a term that describes the relationship of energy consumption to outdoor temperatures. "Heating or cooling degree days" are deviations of the mean daily temperature from 65° F. For example, for a day with a mean temperature of 40°F, the "heating degree days" would be 25 and the "cooling degree days" 0. Annual heating degree days are the sum for the year. Greater number of heating degree days means greater fuel requirements.

*** Revised by W. J. Koss, NOAA, September 7, 1988.

TRANSPORTATION FUELS

Prior to the decade of the sixties energy used for transportation was on a par with that used for industrial production within the state.[8] In the ensuing decades, energy fueling the transportation end-use sector has grown much faster than industrial usage and constitutes the largest use for energy in the state. Both highway gasoline and diesel fuel consumption reached record heights in 1989 (Table 3). The California State Energy Commission takes some solace in the fact that the amount of btu consumed per mile is declining; from 1973 -1987 vehicle fuel use rose 22% while vehicle miles traveled climbed 74%.[9] (Figure 3)

Table 3
California Transportation End Use
(in 10^{12} Btu)

	1983	1984	1985	1986	1987	1988	1989
Net gasoline	1418	1413	1445	1543	1576	1612	1630
Net aviation fuel	318	348	379	392	390	427	458
Taxable diesel fuel —public highways	168	201	207	218	174	244	265
Rail diesel	41	27	31	31	30	26	30
Net bunkering fuel	316	390	274	267	347	357	348
Military	35	40	33	35	28	29	30
Natural gas-pipeline fuel	n.a.	11	12	15	13	20	20
Total*	2307	2431	2384	2499	2565	2715	2781

n.a.: not available
* Some electricity is used for mass transit; however the amount is not monitored on a state-wide basis and hence does not appear in this table or in Figures 1 and 2.
Source: Petroleum Marketing Annual 1988 DOE/EIA-0487(89); Fuel and Kerosene Sales, DOE/EIA, 1989: Quarterly Oil Report, Fourth Quarter 89 (Net gasoline and aviation fuel), California Energy Commission, Sacramento, CA.

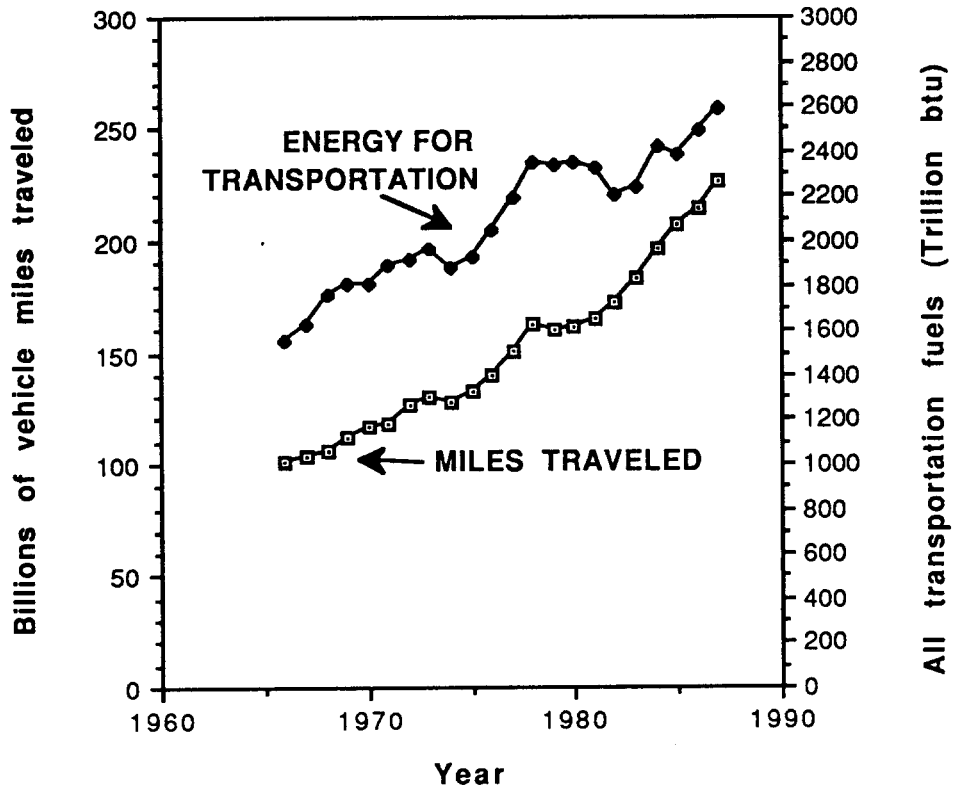

Figure 3. Growth of California's transportation usage

Source: "State Energy Data Report 1960-1987," DOE/EIA-0214(87), Table 46 April 1989; "Energy Efficiency" (Committee Report), California Energy Commission, Sacramento, CA P400-90-003, Appendix A-2, September 1990.

For the fifteenth consecutive year vehicle travel on California highways increased (4.6%).[10] *New* automobile registrations were down slightly; however *new* commercial registrations were up 2.2%. For the five years prior to 1989 the number of licensed drivers in the state increased 2-3.4% annually reflecting a general population increase; in 1989 the number rose 3.4% to 19.6 million.[10]

Informal forecasts suggest that by 2005 the state population and the number of car registrations will increase by about 20% while vehicle miles traveled will grow by 75% and congestion on state roads by 200%.[11]

OIL AND GAS PRODUCTION

California's oil production continued the decline that started in 1986. Despite the rising price of oil in 1989, the price of crude oil had small effect on production. The added cost of raising steam for production and the low posted price associated with California oils due to their low quality apparently were more important factors. The 1989 production decline of 6% was principally in onshore fields that comprise almost 84% of total state production of 364 million barrels. The only increases recorded were in offshore fields, specifically the Sockeye (Federal), Belmont (State) and Point Pedernales (Federal) fields.[12] Enhanced recovery (78% steam injection) continued to account for almost two-thirds of California's oil production.

Production at Point Arguello federal OCS field discovered in 1981 remained stalled throughout 1989 by environmental concerns related to transport of the oil to shore. It is the largest offshore field discovered in the U. S. with reserves estimated between 300-500 million barrels.[12] The consortium made up of eighteen companies had invested approximately $2 billion in its development,[13] which consists of three offshore platforms that can accommodate up to 154 wells. It has been ready to produce for two and one-half years. In 1989 Chevron and partners sued the California Coastal Commission to overturn the agency's denial of a permit to transport oil by tanker to the Gaviota marine terminal on an interim basis[14] and at year's end the principal companies involved prepared to "write-down" their investment.

Natural gas production also decreased and in 1989 was slightly greater than half of production in the record year of 1968. As demand for gas rose by 8% in 1989, the difference was made up by increased imports from out-of-state sources. California natural gas proved reserves including federal offshore reserves stood at 5 Tcf at year-end; for reference the total U. S. reserves were 175 Tcf.[15]

NATURAL GAS SUPPLY

The growing use of natural gas by oil producers for steam production in enhanced recovery operations and by cogenerators and self-generators in the state has encouraged a number of pipeline companies to submit proposals to the Federal Energy Regulatory Commission (FERC) in order to bring additional gas into the state. In 1988 there were eight proposals from various companies under

consideration, and by the end of 1989 the number had been reduced to six.* The proposed additions to gas capacity greatly exceeds anticipated demand although California's incremental demand for natural gas is projected to grow between 0.5 Bcf/d and 1.8 Bcf/d by 2000[16]; the wide spread in the estimate attests to its contentious nature.[17] The largest market for the new gas is for electrical generation. In contrast to enhanced oil producers, electrical generators are more willing and likely to sign long-term contracts for the gas (greater than 5 years) and are less likely to switch to oil (lease crude in the case of EOR operators) to generate steam in response to price fluctuations. Gas turbines are the choice of cogenerators who normally do not have a fuel-switching capability.

At year's end several proposals had been issued a final certificate by FERC:

- Kern River Gas Transmission, a 904 line from Kemmerer, Wyo. to Bakersfield, CA with an initial capacity of 0.7 Bcf/d and a completion scheduled for late 1991.[18]
- Wyoming-California Pipeline Co., a 1000 mile line from SW Wyoming to near Bakersfield, CA with an initial capacity of 0.5 Bcf/d and a completion scheduled for late 1991.

Earlier in the year Kern River and Mojave Pipeline Co. agreed to merge the interstate pipelines planned into a single pipeline at Daggett, CA. Mojave, who received an optional, expedited certificate from FERC, would then move gas from the southwestern states into California. Mojave Pipeline Co.'s line would have an initial capacity of 0.4 Bcf/d.[19]

The unusually large amount of "unaccounted" gas shown in Figure 1 is inexplicable; however, it may be related to difficulties in exactly tracking the growing amount of gas being transported for others by the major pipeline companies serving the state.

ELECTRICAL POWER

Source of Supply

Again the two largest sources of power to the State are out-of-state electrical purchases and in-state generators fueled by natural gas (Table 5). Together they comprise more than half of the electricity transmitted by the state's utilities. Utility transmissions to customers remained close to 1988 levels; however the growth of

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* Kern River, Tenneco and Williams Cos.; Wycal, Coastal Corp; PGT, Pacific Gas and Electric Co.; Altamont, Petro-Canada Amoco and Shell; Mojave, Enron and El Paso Natural Gas Co.; El Paso Expansion, El Paso Natural Gas Co.

cogenerators and self-generators, who supply their own—usually large, needs—suggests that total electrical consumption in 1989 probably exceeded that of 1988. Transmission losses shown in Figure 1 are abnormally low as compared to those recorded in previous years. The low values are almost certainly incorrect and most likely reflect errors in the data reported by monitoring agencies.

The continuing drought throughout the Western part of the United States had an impact on California utilities. Although a small part of California power comes from state hydro-sources, out-of-state imports (principally from the Bonneville Power Administration (BPA) which manages Pacific Northwest electrical systems) are essentially from hydroelectric sources. Because of low rain fall mid-year BPA announced that it would cease selling surplus power to Southern California Edison and three cities, Burbank, Glendale and Pasadena. Instead BPA agreed to trade power with the California utilities. It will send power south during peak demand in California and receive power during off-peak hours.[20] As California still has surplus generating capacity, there were ample resources in California to meet demand. Cogenerated electricity sold to utilities fell in 1989 (compare Figure 1 and 2) possibly because of capacity factor differences and incomplete reporting.[21] The amount of electricity used by the cogenerators themselves, as well as the amount of self-generated electricity used by the industrial sector, is not monitored by state or federal agencies; thus it has no expression in the data in tables or figures presented here except that the fuels used to generate the power are included in the energy used by the industrial and non-energy sectors.

Table 4

California Electrical Generating Capacity[22,23]

Primary Energy Source	Capacity (GWe)
Utility*	
Petroleum	3.09
Gas	21.36
Water	12.41
Nuclear**	5.64
Other (principally geothermal)	2.00
SUB-TOTAL	44.50
Cogeneration***	4.92
Wind	1.30
Solar	0.22
Other (biomass, landfill gas, small hydro municipal solid waste, etc.)	0.87
TOTAL	51.81

* Summer capability as of December 31, 1989

** Including Rancho Seco nuclear plant shut down June 1989

***Firm and as available contractual capacity and self-generation capacity

Table 5

Sources of California Utilities' Electricity –1989

Source		Net electrical energy (trillion Btu)
Imports		177
Out-of-state coal facilities	59	
Purchases	118	
Fossil fuels		207
Natural gas	175	
Oil	32	
Nuclear power		111
Hydropower		101
Geothermal power		33
Windpower		7
Cogeneration		70
TOTAL		706

Nuclear Power

Nuclear power's contribution to net utility electrical generation in California increased 5% (Table 4) despite the shutdown of the Rancho Seco nuclear plant near Sacramento mid-year. Improved capacity factors at Diablo Canyon nuclear facility more than compensated for the loss of Rancho Seco, which had a poor performance record in the years prior to its closing.

Nuclear plants operating during 1989 in the state* include:[24]

Plant	Capacity (GW Gross)	Type	Year of Commercial Operation
Rancho Seco	0.966	PWR†	1975
Diablo Canyon 1	1.125	PWR	1985
Diablo Canyon 2	1.130	PWR	1986
San Onofre 1	0.456	PWR	1968
San Onofre 2	1.127	PWR	1983
San Onofre 3	1.127	PWR	1984
Total	5.931		

† Pressurized water reactor.

The shut down of Rancho Seco was a consequence of a referendum by Sacramento voters. Although it had survived referenda in the past, the June referendum was decisive with almost 200,000 voters voting 53% to 47% to shut it down.[25] The vote was the first time in sixteen attempts that a plant had been shut down in the U. S. as a result of a referendum which is clearly a reflection on the poor performance of the plant. The operating utility, Sacramento Municipal Utility District, plans to contract for additional capacity from other utilities in the state. At the end of the year, directors of the utility were considering refitting the plant with gas-burning units as has been done elsewhere in the country, e.g. at the former Midland nuclear power plant in Michigan.

* In addition, Southern California Edison Co. has a partial interest in the Palo Verde nuclear complex in Arizona.

Renewable sources of electricity

Geothermal

Generating capacity at the Geyser Geothermal Field reached an all time high of 1908 megawatts, net with the completion of the J. W. Aidlin power plant of 23 megawatts, gross.[12] Nonetheless, the amount of steam produced at the field fell for the second year in a row indicating that the field as a whole is in a state of decline. Symptoms include accelerated pressure decline of existing wells probably due to increased interference of wells with each other, e.g. the diversion of steam from an existing well into a new well. Other problems have also developed reducing the amount of steam produced: production of corrosive steam in portions of the field and higher levels of noncondensible gases in the steam. Thus despite the usual description, geothermal resources are depletable and are not renewable in the same sense as solar-related resources.

Problems continue to plague the Bottle Rock geothermal power plant between Clear Lake and Calistoga that started up in April 1985. The $108.2 million plant designed to produce 55 megawatts on the State Department of Water Resources property at the Geysers is producing 20 megawatts. A recent report indicates that the Bottle Rock area does not have the 30 year steam supply planned on prior to development. Power that is produced is reported to be more expensive than an equivalent amount of purchased power.[26]

The Coso Geothermal Resource Area in the China Lake Naval Weapons Center, Inyo County, saw the finish of the first phase of its development by California Energy Co. Inc., San Francisco. By the end of 1989 nine power plants were on line with a capacity of 230 megawatts, net. The federal land is leased from the U. S. Bureau of Land Management. The power is sold to Southern California Edison Co.

Other new plants that came on line in 1989 are the Wendel Geothermal field (30 MW) which provides hot fluids to preheat feedwater for a biomass-fired boiler and a twin power plant facility.[12] Construction and testing occurred at many locations within the state—at the Casa Diablo Geothermal Field in Mono Co, at the Salton Sea Geothermal field and in Lake, San Bernardino, Plumas, Sierra and Modoc Counties.

Windpower

Electrical power from the state's windpower facilities increased 14% in 1989—from 1.82 billion kWh to 2.079 billion kWh.[27] This was accomplished through additions to installed capacity (64 MWe), return-to-service of turbines that were inoperative and a slight increase in the average state capacity factor to 18% from 17%

(Table 6). The average, statewide capacity factor is the ratio of actual output to the amount of energy that could be produced if operated at full rated power. The average would have been considerably higher if Fayette and FloWind, two of the largest project operators in the state, had posted higher efficiencies; Fayette with 141 MWe capacity registered only a 5% capacity factor and FloWind with 139 MWe, 14%.[27]

FloWind Corp. filed for reorganization under Chapter 11 of the federal Bankruptcy Act in 1988. FloWind's vertical-axis windmills operate in the Tehachapi Mountains of Southern California and in the Altamont Pass area 50 miles east of San Francisco. The company operates the wind farms for 1600 limited partners. In 1989 the corporation negotiated with its insurance company for repair and upgrade of its turbines in order to increase output and revenues and thus to begin to pay off its $50 million debt.[28] The company's financial troubles relate to a heavy debt structure that limited maintenance and upgrading of the turbines and the earlier loss of state and federal tax advantages in the form of credits.

Horizontal turbines in the 51-100 kw capacity range comprise more than half the total number of machines installed in California; however in 1989 new installed capacity was chiefly machines rated greater than 150 kw. In 1989 the bulk of new capacity was of foreign manufacture with Japanese manufacturers dominating the list. Nonetheless, Danish turbines have been in the past and remain the principal foreign supplier of turbines to the state's wind industry. Turbines of foreign origin made up 48% of total capacity and provided 52% of the power generated in 1989.[27]

Ironically installation of new wind turbines is being challenged by environmentalists, who have been the strongest advocates of renewable forms of energy in the past. These new opponents say the rotors threaten the large predatory birds, particularly golden eagles, hawks and California condors. The Sierra Club and Audubon Society in opposing a proposed wind facility in Los Angeles County by Zond Corp. argued that wind energy is unreliable and represents only "a tiny amount of (energy) saving"[29] which is a turn-about from earlier positions. While it is true that the large raptors are killed by wind turbines, the toll has been small compared to that associated with radio towers, electric transmission lines and oil spills, e.g. 7,782 birds died in 14 nights at the site of a single television tower in Florida.[29] Other activist groups have joined the opposition; however their arguments are driven by concerns over lowered property values within view of the farms since wind turbines are considered unsightly.

Table 6

Windpower Installations in California as of January 1

Location	Capacity (MW_e)				Number of turbines			
	1987	1988	1989	1990	1987	1988	1989	1990
Altamont Pass area, 45 miles east of San Francisco	584	654	623	659	6219	6615	6062	6242
San Gorgonio Pass, Riverside Co. near Palm Springs	295	254	206	224	4155	3830	3322	3388
Tehachapi Pass, Kern Co.	355	393	370	417	4175	4480	4007	4414
Mojave Desert, Kern Co.	0	0			0	0		
Boulevard, San Diego Co.	0.8	0.8			36	36		
Carquinez Strait, Solano Co.	0	0.63	2	2	0	6	66	62
Pacheco Pass, San Benito Co.	0.5	0.5				20		
Salinas Valley	0.16	0.16			4			
TOTAL	1235	1304	1202	1302	14609	14991	13457	14106

Source: California Energy Commission, Results from the Wind Project Performance System 1985 Annual Reports, August 1986, 1987 and Sam Rashkin, personal communication, 1989 and 1990.

Solar Electricity

The world's largest solar electric installation at Kramer Junction, CA, some 140 miles northeast of Los Angeles, began a $1.2 billion expansion in 1989.[30] The 194 MW facility built by Luz International Ltd. uses parabolic mirrors that track the path of the sun across the sky. Investors include Potomac Electric Power, Baltimore Gas and Electric and Prudential Insurance.[31] In order to have a steady output, the solar heat supply is supplemented with a boiler fueled by natural gas. In order to qualify

for favorable power purchase terms under Federal law, a solar plant built by an independent power producer must derive 75 percent of its heat from a renewable source, and the Kramer Junction plant meets those qualifications. The company's aim is to reduce costs to 8 cents per kwh thereby becoming competitive with conventional peaking plants used during hours of peak demand. Critical to the success of the project has been finding firm markets for the power. Southern California Edison has signed 30 year contracts for power produced to date, and by year-end San Diego Gas and Electric had signed a 30 year, $600 million contract to purchase an additional 80 megawatts of power starting in 1993.[32]

APPENDIX A

Energy balance for 1989 (Figure 1)

			(10^{12} btu)
SUPPLY			
Electrical Imports			288
Wind			7
Hydro			112
Cogenerated electricity (fuels included in oil and gas supplies below)			-
Geothermal			173
Nuclear			337
Natural gas			2076
Less: unaccounted for gas and net storage additions			-146
Coal			57
Petroleum			4439
Less exports			-424
Total			6919
DISPOSITION			
Useful energy			2912
Residential/commercial		982	
Industrial		1235	
Transportation		695	
Non-energy uses			237
Rejected energy			3840
Residential/commercial		421	
Industrial		411	
Transportation		2086	
CA electric utility generation		803	
Fossil fuels	426		
Nuclear	226		
Hydro	11		
Geothermal	140		
CA transmission losses		8	
Out-of-state elec. generation and transmission losses		111	
Cogeneration (included in industrial)			-70
Total			6919

APPENDIX B

Data Sources for California Energy Supply (1989)

Production	Source
Crude Oil including Federal Offshore and Lease Condensate	Ref. 12.
Associated and Nonassociated Natural Gas (marketed, dry)	Ref. 33, Table 45, Summary Statistics for Natural Gas - California.
Electric Utility Fuel Data	Ref. 34, Table 15, Total Consumption of Petroleum to Produce Electricity; Table 16. Consumption of Gas to Produce Electricity.
Electrical Generation	
Oil, gas, hydro, nuclear, and other	Ref. 34, Tables 8,9,10,11, and 12, Net Generation by Petrol. Gas, Hydroelectric Power, Nuclear Power and Other.
Wind	Ref. 27
Cogeneration	Andrea Gough, California Energy Commission, personal communication, Oct. 12, 1990.
Imports	
Natural Gas	
Foreign	Ref. 33, Table 9.
Domestic	Ref. 33, Table 45.
Crude Oil	Ref. 35, Table 1, California
Foreign and Domestic	Petroleum Summary.

Oil Products Foreign and Domestic	Ref. 35, Table A-1, California Petroleum Fuels Market Activity.
Coal	Ref. 36, Table 24, Coal Consumption by Census Division and State.
Electrical Power Net Exchange	Andrea Gough, California Energy Comm., personal communication, Oct. 12, 1990.
Coal	Ibid

Exports

Oil Products Foreign and Domestic (not including bunkering fuel supplied at California ports)	Ref. 35, Table A-1.

APPENDIX C

Data Sources for California End Uses (1989)

Net Storage	
Natural Gas	Ref. 33, Table 45.
Unaccounted for Natural Gas	Ref. 33, Table 45.
Transportation	
Crude Oil	
Gasoline, Aviation and Jet fuels	Ref. 35, Table 1.
Taxable Diesel Fuel (for public highways)	Ref. 37, Table 11, Sales for Transportation Use: Distillate Fuel Oil and Residual Fuel Oil, 1989.
Vessel Bunkering (includes international bunkering)	Ibid.
Rail Diesel	Ibid.
Military Use	Ref. 37, Table 12, Sales for Military use, Off-highway and all other uses: Distillate fuel, Residual Fuel Oil, and Kerosene, 1989.
Natural Gas	
Pipeline fuel	Ref. 33, Table 45.
Industrial, Government, Agriculture, etc.	
Natural Gas (includes lease and plant fuel)	Ref. 33, Table 45.

APPENDIX C (Continued)

Coal	Ref. 36, Table 24.
Electricity	Ref. 34, Table 34, Sales of Electricity to Ultimate Consumers by Class of Service, Year to date.
Crude Oil	By Difference.
Non Energy Applications	
Crude Oil and LPG	
Asphalt	Ref. 38.
Petrochemical Feedstock	Ref. 39, Table 12, PAD District V, Supply, Disposition and ending stocks of Crude Oil and Petroleum Products, 1989.
Waxes, Lubricating oils, Medicinal uses, Cleaning	Ref. 35, Table A-5, California Refinery Activity by Type and Area.
Natural Gas	
Fertilizer	Russell Reinking, Unocal Chemical Div., UNOCAL Oil Co., personal communication, December 3, 1990.
Residential and Small Commercial	
Natural Gas	Ref. 33, Table 45.
Crude Oil and Other Oils (kerosene, residual, and distillate)	Ref. 37, Table 6, Sales of Kerosene by End Use; Table 5, Sales of Residual Fuel Oil by End Use; Table 4, Sales of Distillate Fuel Oil by End Use.

APPENDIX C (Continued)

LPG	Ref. 39, Table 12.
Miscellaneous "Off highway" Diesel	Ref. 37, Table 4.
Electricity	Ref. 34, Table 34

APPENDIX D

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
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	6.636 per barrel
Synthetic Rubber and Miscellaneous	
LPG Products	4.01 per barrel

Assumed Conversion Efficiencies of Primary Energy Supply

Electric Power Generation	
Hydro Power	90%
Coal	30%
Geothermal	18%
Oil and Gas	33%
Uranium	32%
Transportation Use	25%
Residential/Commercial Use	70%
Industrial Use	75%

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