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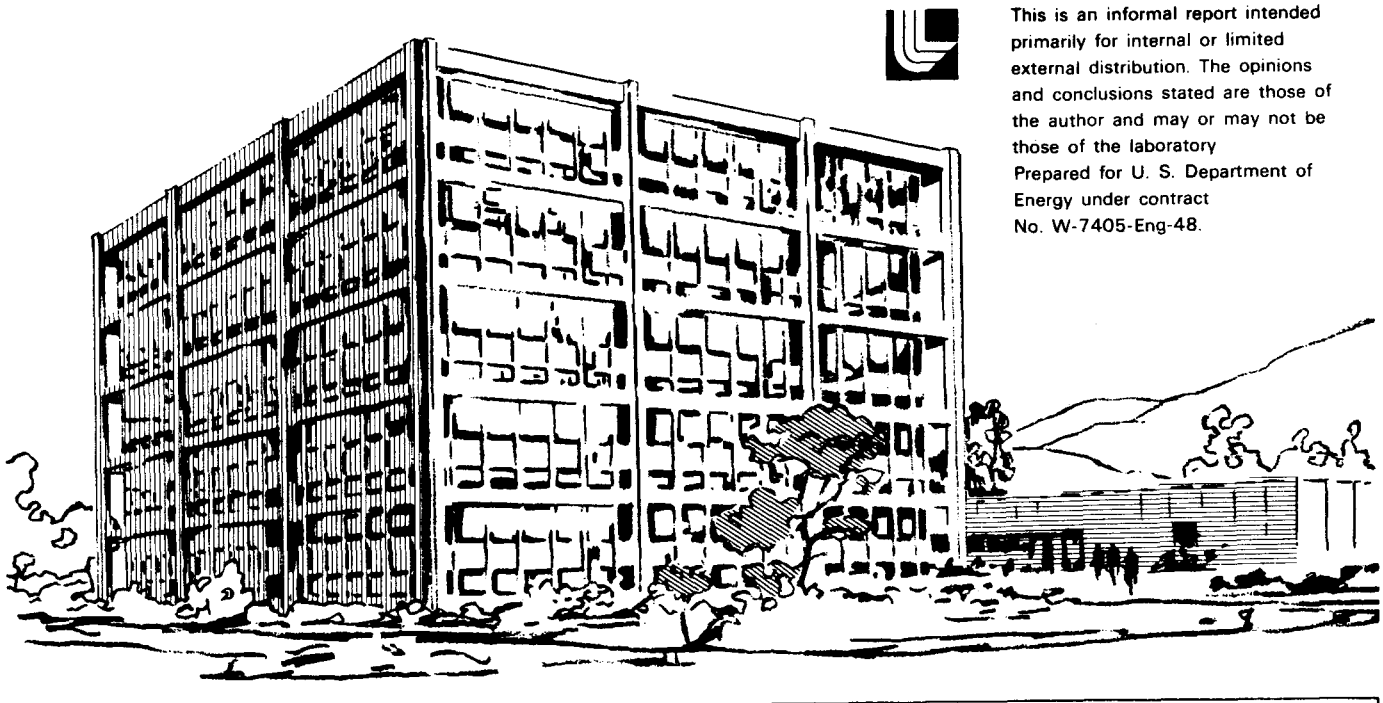
CALIFORNIA ENERGY FLOW IN 1977

Iris Y. Borg

July 20, 1979



CALIFORNIA ENERGY FLOW IN 1977

Abstract

The supply and use of various forms of energy in California in 1977 has been collected and assembled in an energy flow chart. Overall energy consumption increased 5% in 1977 over 1976; the bulk of the increase was possible because of larger imports of foreign and increased production of domestic crude oil. The natural gas supply remained constant and because of the mild winters of 1976-7 and 1977-8 was used to a greater degree for electrical power generation. The 1977 drought seriously impacted both imported and domestic hydroelectric power. The power deficit was met by increased use of gas and especially oil as boiler fuels. Coal use remained constant; although out-of-state power from coal-fired plants in Arizona, Nevada and New Mexico increased slightly. Use of energy in the transportation sector increased 10%; use of motor gasoline and aviation gasoline and jet fuels increased to the same degree.

Introduction

Energy flow diagrams are a convenient device to express the relation between supply and end-use on an annual basis. They can be constructed for the world, a single country or state providing the data are available. Generally they are useful for monitoring changes from year to year on the condition that the same conventions in construction of the diagrams are observed. In view of the complexity of the whole energy picture, it is not surprising that considerable differences are apparent in flow diagrams prepared by different analysts for the same year. The reasons relate to the many different avenues that may be taken to simplify the picture.

In order to compare the 1977 energy flow for California with that constructed for 1974 and 1976, [1,2] as far as possible similar data sources and conventions have been followed. Thus it differs in various ways from its counterpart for 1977 published by the California Energy Commission (CEC).[3] In addition, much of the data contained in the diagram comes from federal and state agencies rather than from the data base maintained by the CEC.

Source of Data

Tables 1 and 2 contain detail on the sources of information used to construct the 1976 and 1977 flow diagrams. In some instances, California data were obtained by inquiry to the proper Energy Information Administration of the Department of Energy. This was necessary in those instances where regional or PAD (Petroleum Administration for Defense) district data were reported in published documents rather than data by state. Comparison of data from several sources, e.g., American Gas Association, U.S. Department of Energy and California Energy Commission, generally revealed minor differences.

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(1) E. Behrin and R. Cooper, California Energy Outlook, Lawrence Livermore Report UCRL-51966 Rev. 1 (February 6, 1976).

(2) I. Y. Borg, California Energy Flow in 1976, Lawrence Livermore Report UCRL-52451 (April 20, 1978).

(3) Quarterly Fuel and Energy Summary 3, No. 4, Fourth Quarter 1977 (July 1979), California Energy Commission, Sacramento, CA.

Table 1

DATA SOURCES FOR CALIFORNIA SUPPLY

Production	Ref. (4)
Crude Oil including Federal Offshore Lease condensate Associated and nonassociated natural gas	63rd Annual Report of the State Oil and Gas Supervisor, California Division of Oil and Gas - No. PRo6 (1977) Gas No PRo6 (1977)
Electrical generation (Hydro, nuclear, oil, gas, geothermal and other)	Ref. (5) Power Production, Consumption and Annual, Energy Data Reports, DOE/EIA 0049-1, May 1978 Department of Energy, Washington, D.C.
Imports	Ref. (6)
Gas (foreign and domestic)	1978 California Gas Report (1979) Published by California Utilities
Crude oil (foreign and domestic)	Ref. (7) Crude Petroleum, Petroleum Products and Natural Gas Liquids, 1977 Energy Data Report DOE/EIA - 0108/77, December 8, 1978, Department of Energy, Washington, D.C.
Oil products (foreign and domestic)	Ref. (3), Table W
Coal	Ref. (8) Bituminous Coal and Lignite Distribution, Quarterly Energy Data Reports, February 6, 1978 and April 14, 1978
Electrical power	Ref. (3) Table O (coal) Table A (Hydro)
Exports	
Oil products (foreign and domestic)	Ref. (3)

Table 2

DATA SOURCES FOR CALIFORNIA END USES

Transportation	
Crude oil	
Refinery output of gasoline aviation fuel and jet fuels	Ref. (7) Table 16 broken down by state by J. Harris (DOE, Washington, D.C.)
Taxable diesel fuel (i.e., for public highways	Ref. (9) California Statistical Abstracts, Table J3, p. 119, (1978), State of California Documents Division, Sacramento, CA
Rail diesel	Ref. (10) Sales of fuel oil and kerosene, 1977 (Table 10) Energy Data Reports, DOE/EIA - 0113/77, October 25, 1978, DOE, Washington, D.C.
Military use	Ref. (10) Table 12
Vessel bunkering	Ref. (10) Table 11
Exports of gasoline, jet fuel, and Bunker C	Ref. (3)
Natural gas Transmission and pipeline	Ref. (11) Estimate from I. Y. Borg, California Energy Flow in 1976, Lawrence Livermore Laboratory Report UCRL-52451 (April 20, 1978)
Non-energy applications	
Crude oil and LPG Asphalt	Ref. 12 Sales of Asphalt in 1977, Energy Data Report (Table 5), DOE, Washington, D.C. (July 27, 1978).
Synthetic rubber and other miscellaneous petrochemical uses	Ref. 13 Sales of LPG and Ethane in 1977, Energy Data Reports, (Tables 7-8), DOE/EIA - 0115/77 (October 25, 1978)
Waxes, lubricating oils, medicinal uses, cleaning hydrocarbon	Estimates from Ref. (11)

Table 2 (continued)

Natural gas	
Fertilizer	Ref. 14 Henry Lippitt, Jr., Bulletin No. 79-19, May 19, 1978 California Gas Producers Association, Los Angeles, CA 90017
Net storage and field use	
Natural gas	Ref. (4)
Residential and small commercial - (Priority #1)	
Natural gas	Ref. (15), Gas Facts, 1977 (Table 64) American Gas Association, Arlington, VA (1978). Also Refs. (6) and (15)
Crude oil and other oils	
LPG (heating)	Ref. (13) Table 3
LPG (NG Substitute by utilities)	Ref. (13) Table 6
Fuel oil and kerosene	Ref. (10) Table 5
Residual and distillate oil (heating)	Ref. (10) Tables 6 and 7
Electricity	Ref. (9) Table K-1
Industrial, government, agriculture, etc.	
Natural gas	Ref. (16) Natural gas production and consumption: 1977 Annual Energy Data Reports, DOE/EIA - 0131/77 (October 18, 1978). (Also Ref. (14).)
Coal	Ref. (8)
Electricity	Ref. (9) Table K-1
Electric transmission loss	8.5% assumed
Crude oil	By difference

Compilation of Data

Since 1976 several changes have been made in records kept by utilities in California. Former classification of users, such as residential, commercial, firm industrial, interruptible industrial, etc., has been supplanted by a classification based on priority. The adoption of the priorities, especially with respect to natural gas users, was in anticipation of future curtailments. In order to preserve continuity which would allow meaningful comparisons from year to year, a dual classification scheme was maintained by the utilities during 1977. Nonetheless, transfers from one category (or rate schedule) to another have occurred. For example, in 1977 many former "interruptible industrial" natural gas customers were reclassified to commercial schedules with higher priority. Thus all comparisons of usage of these broad classes of users are attended with uncertainty. In Fig. 1, the energy flow diagram for 1977, residential and small commercial users, all with the highest priority, are combined and separated from other lower priority uses.

We continue to maintain a "non-energy" category of end-use. Its make-up is described in Table 2. It is set apart from other end uses by the fact that fuels contributing to it are not burned or their energy dissipated as heat.

Imported electrical power is recorded in Fig. 1 as derived from hydroelectric facilities (58×10^{12} Btu) and coal-fired plants (150×10^{12} Btu). In this instance the quantities recorded are the energy embodied in the fuels. The actual power transmitted across state boundaries corresponds to 52×10^{12} Btu and 48×10^{12} Btu respectively. The out-of-state

CALIFORNIA ENERGY FLOW – 1977 (10^{12} Btu)

Total Energy Consumption 6000 X 10^{12} Btu

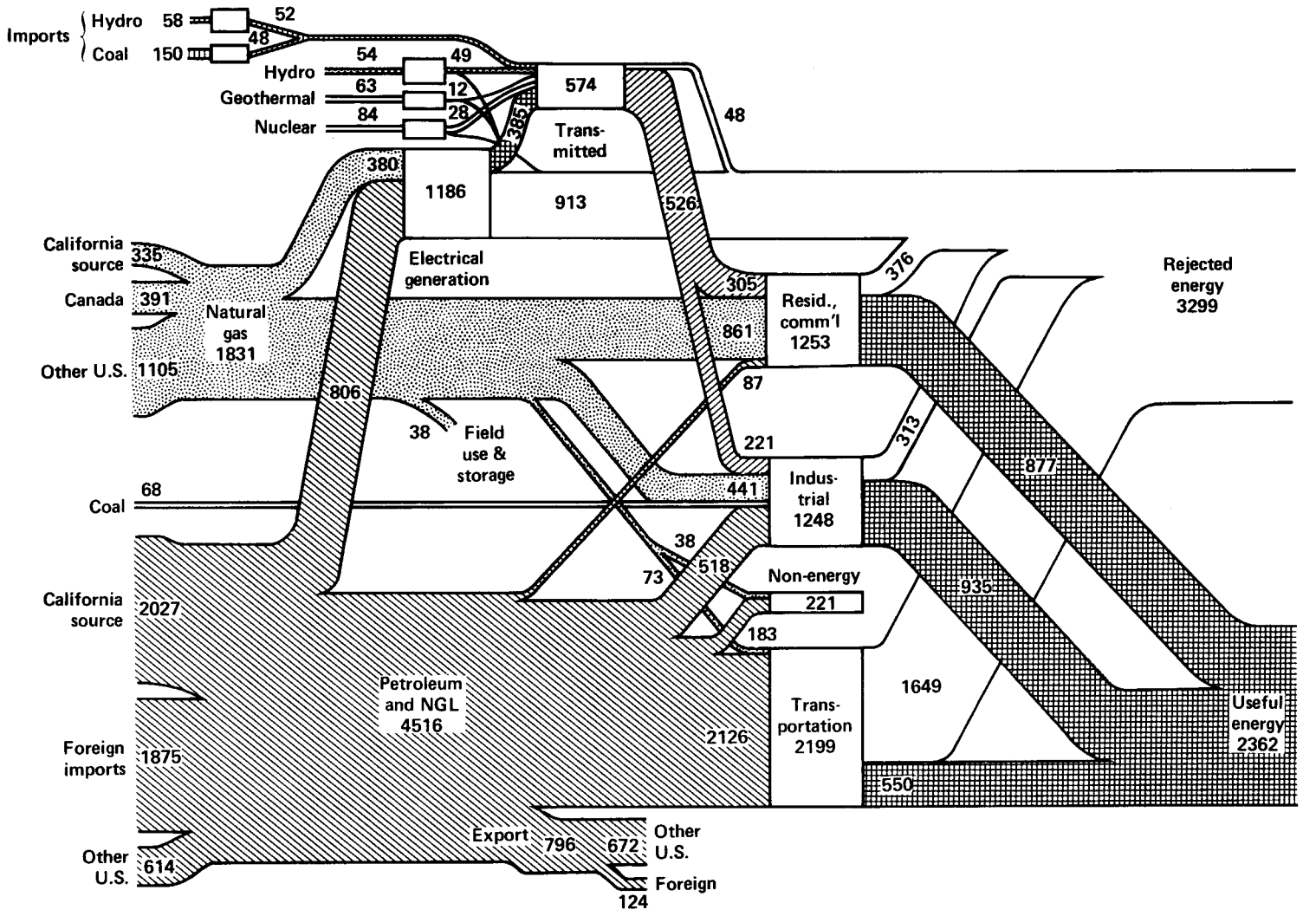


FIGURE 1

coal-fired plants are at Four Corners, Farmington, New Mexico, operated by Arizona Public Service Company; the Navaho Plant at Page, Arizona and operated by the Salt River Project; and the Mohave Plant, Nevada, operated by the Southern California Edison. There are no coal-fired electrical generating facilities in California.* Out-of-state hydroelectric power is from the Pacific Northwest (Bonneville Power Administration) and the Southwest (principally Hoover and Davis Dams on the Colorado River). Parker Dam generators also on the Colorado River are in California.

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

Comparison with 1976

The largest changes in supply and consumption of energy during 1977 are related to the 1977 drought. In addition, both 1976 and 1977 were climatically mild years. The unseasonably warm winters of 1976-77 and 1977-78 led to less-than-average space heating requirements. The drought throughout the Pacific Northwest resulted in less than usual power imports from hydroelectric sources (Table 3 and Figure 2) as well as greatly diminished California hydroelectric supplies. Nonetheless, the total amount of transmitted electrical energy remained about the same. This was possible principally by an increase in power generated from oil. Overall the amount

*California utility shares are 21.2% (Navaho), 48% of units #4 and #5 (Four Corners, and 76% (Mohave). Additional power output can be purchased from other shareholders.

Table 3

COMPARISON OF 1977 AND 1976 ENERGY USE IN CALIFORNIA

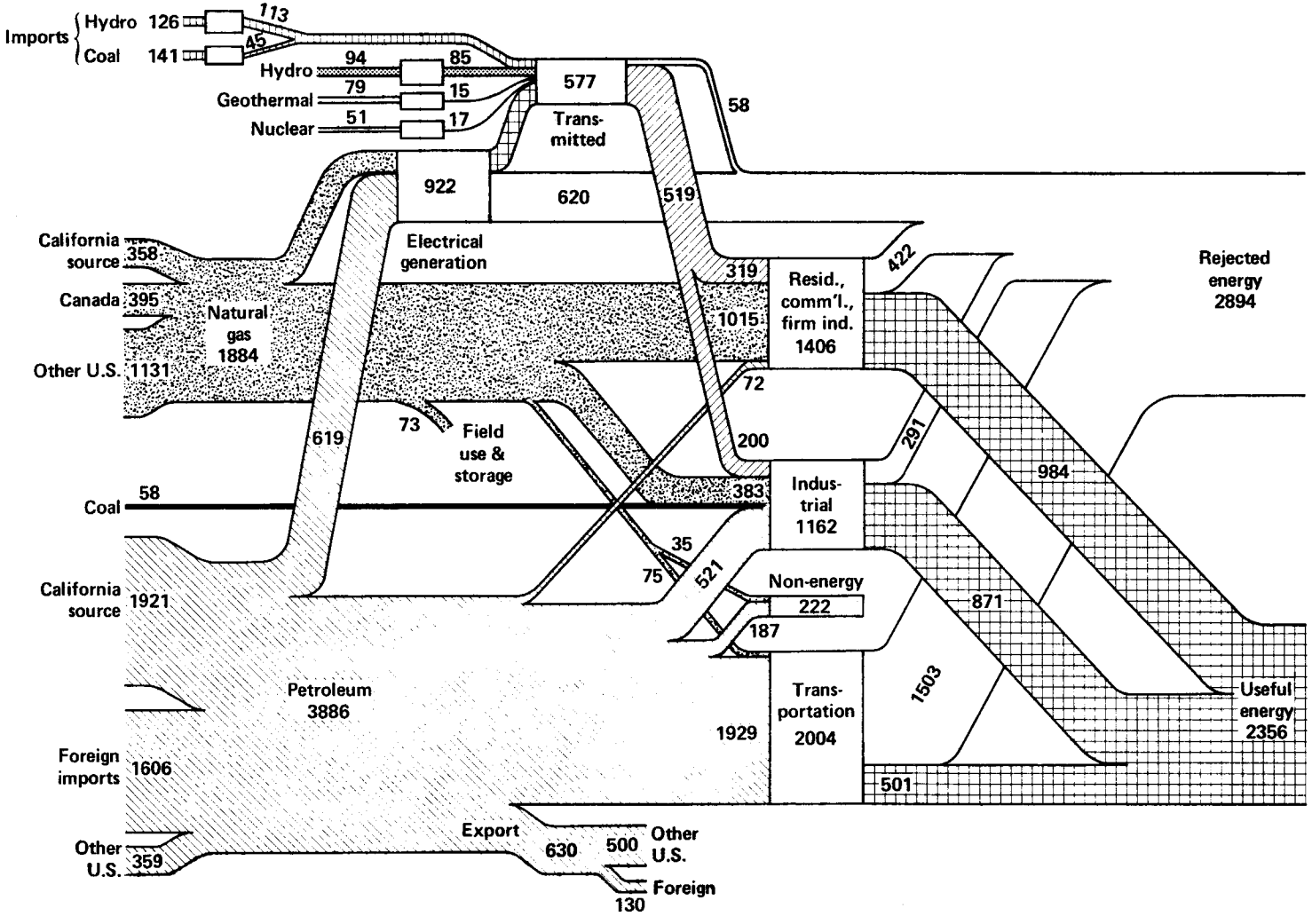
	1976	1977	
	10^{12} Btu		
Natural Gas	1884	1831	Down 2.8%
Crude Oil	3886	4516	
Foreign Imports	1606	1875	Up 16.7%
Other Imports	2280	2641	
Domestic/Foreign Exports	630	796	
Net Use	3256	3720	Up 14.3%
Electricity			
Imports*	158	100	Down 36.7%
Imports**	267	208	Down 22.1%
Hydroelectric	94	54	
Geothermal and Other	79	63	
Nuclear	51	84	
Gas	303	380	
Oil	619	806	
Total Fuel	1413	1595	Up 13%
Total Transmitted Energy	574	577	
Transportation	2004	2199	Up 9.7%

* As imported MW·h (not energy-fuel equivalents)

** As hydroelectric power or coal before conversion to electricity

CALIFORNIA ENERGY FLOW – 1976 (10^{12} Btu)

Total Energy Consumption 5800 X 10^{12} Btu



Data: California Energy Commission; California Division of Oil & Gas, U.S. Bureau of Mines.

FIGURE 2

of fuel consumed to generate the transmitted electrical energy increased about 13%. The reason for the increase despite the relatively constant amount of transmitted electrical power is in the higher efficiency from hydropower conversions ($\sim$90%) than from fossil fuels ($\sim$33%).

Foreign oil imports increased approximately 17% in 1977 despite the start up of the Prudhoe Bay-Valdez pipeline in mid-1977 and subsequent deliveries to California. Combined domestic and foreign crude oil supplies less product exports in 1977 were approximately 14% over 1976. Natural gas supplies were essentially constant. Coal use, chiefly as coke in blast furnaces, remained the same.

As previously noted, changes in end-use classifications make simple comparisons of consumption in traditional categories (residential, industrial, etc.) difficult. From all indications, space heating requirements and hence natural gas consumption were below normal. The nearly uniform, year-to-year supply of natural gas was diverted to electrical power generation - up 25% over 1976.

Overall, California increased its energy consumption 5% during 1977; the total increased from 5700 x 10^{12} Btu to 6000 x 10^{12} Btu. The bulk of the total increase can be attributed to increased crude oil consumption, primarily in the transportation sector.

APPENDIX: CONVERSION UNITS

Energy Source	Conversion factor, 10^6 Btu
Electricity	3.415 per MW·h
Coal	22.8 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	6.636 per barrel
Synthetic rubber and miscellaneous	
LPG products	4.01 per barrel

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