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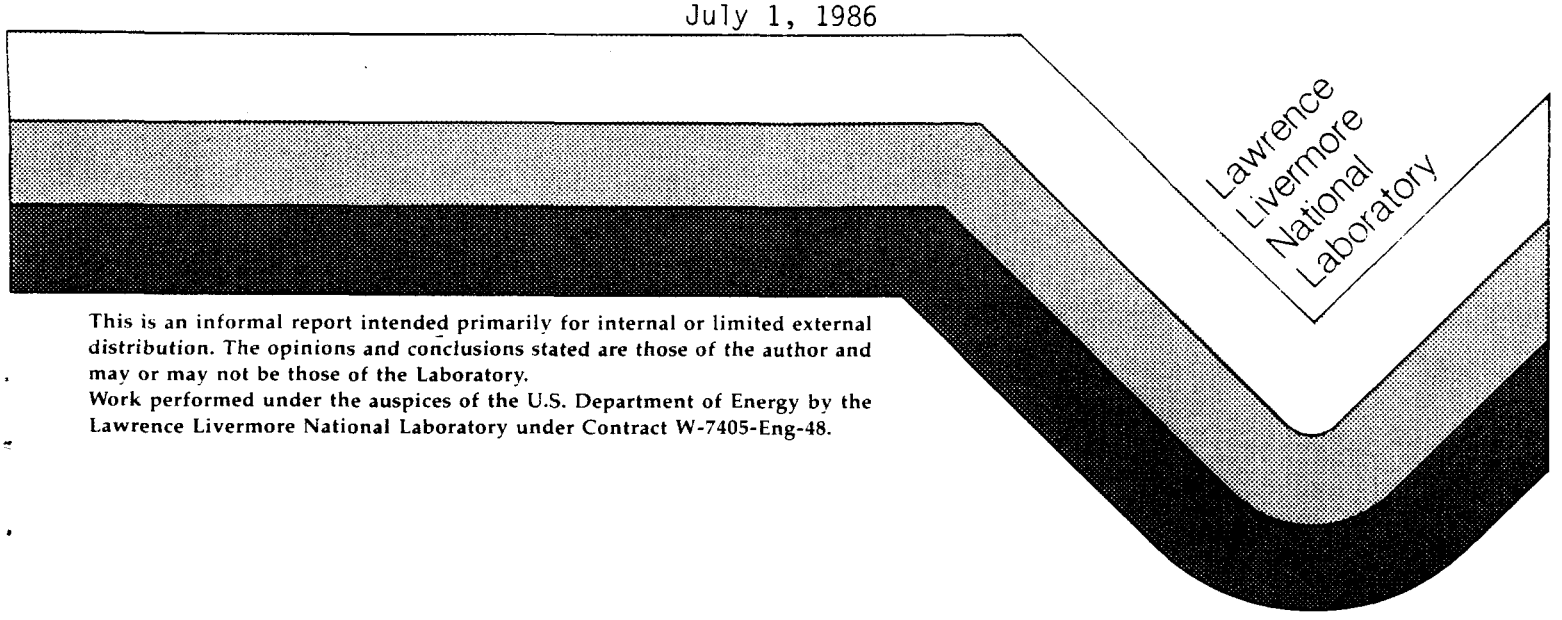
U.S. Energy Flow - 1985

C. K. Briggs
I. Y. Borg

July 1, 1986



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ABSTRACT

The 1985 US energy flow is shown in graphical form using Department of Energy data. It is a convenient graphical device to illustrate supply and end-use data. Energy use in 1985 remained at 1984 levels. A notable change is an increase in transmitted electrical energy made possible by increase in nuclear and coal-fired generation. US nuclear capacity increased by 8 GWe to 78 GWe at year-end. Petroleum use stabilized; net imports dropped nine percent, and domestic production rose slightly for the fourth year. Partial decontrol of natural gas prices was associated with a decline in both wellhead prices and use contrary to predictions. Transportation accounted for two-thirds of petroleum consumption. Despite better average mileage of the automobile fleet, the amount of fuel used increased due to an increase in size of the fleet and the number of miles driven. Due to the fall in the price of crude oil at the end of 1985, the prices of most energy supplies were subject to a downward pressure. Assuming that such trends continue, 1985 may prove to be a turning point in energy usage.

INTRODUCTION

United States Energy Flow Charts tracing primary resource supply and end-use have been prepared by members of the Energy and Resource Planning Group at the Lawrence Livermore National Laboratory since 1972.[1,2] They are convenient graphical devices to show relative size of energy sources and end-uses since all fuels are compared on a common Btu basis. The amount of detail on a flow chart can vary substantially, and there is some point where complexity begins to interfere with the main objectives of the presentation. The charts shown here have been drawn so as to remain clear and be consistent with assumptions and style used previously.

ENERGY FLOW CHARTS

Figures 1 and 2 are energy flow charts for calendar years 1985 and 1984[3], respectively. Conventions and conversion factors used in construction of the charts are given in the Appendix. For comparison with earlier years, consumption of energy resources is given in Table 1. These data represent substantial revisions by DOE (see Monthly Energy Review, March 1983, p. 36).

THE U.S. ECONOMY IN 1985

In 1985 economic growth in the U.S. slowed compared with the rate of growth in the previous year (Table 2). This moderated growth together with continued conservation and efficiency improvements help explain the similarity in 1985 and 1984 U.S. energy consumption.

Although GNP and energy consumption in all forms have tended to be decoupled since 1970 (Figure 3), some economists believe electric load growth is directly related to economic growth. 1985 data appear to bear out that relationship (Figure 3). Electric load growth for 1985 was 2.5%, very close to the GNP growth of 2.3%. The relationship is also affected by the cost of primary energy, and the decline in the real cost of coal in 1985 was a major contributor in keeping electricity prices down and maintaining economic growth.[6]

U.S. Energy Flow – 1985
Net Primary Resource Consumption 74 Quads

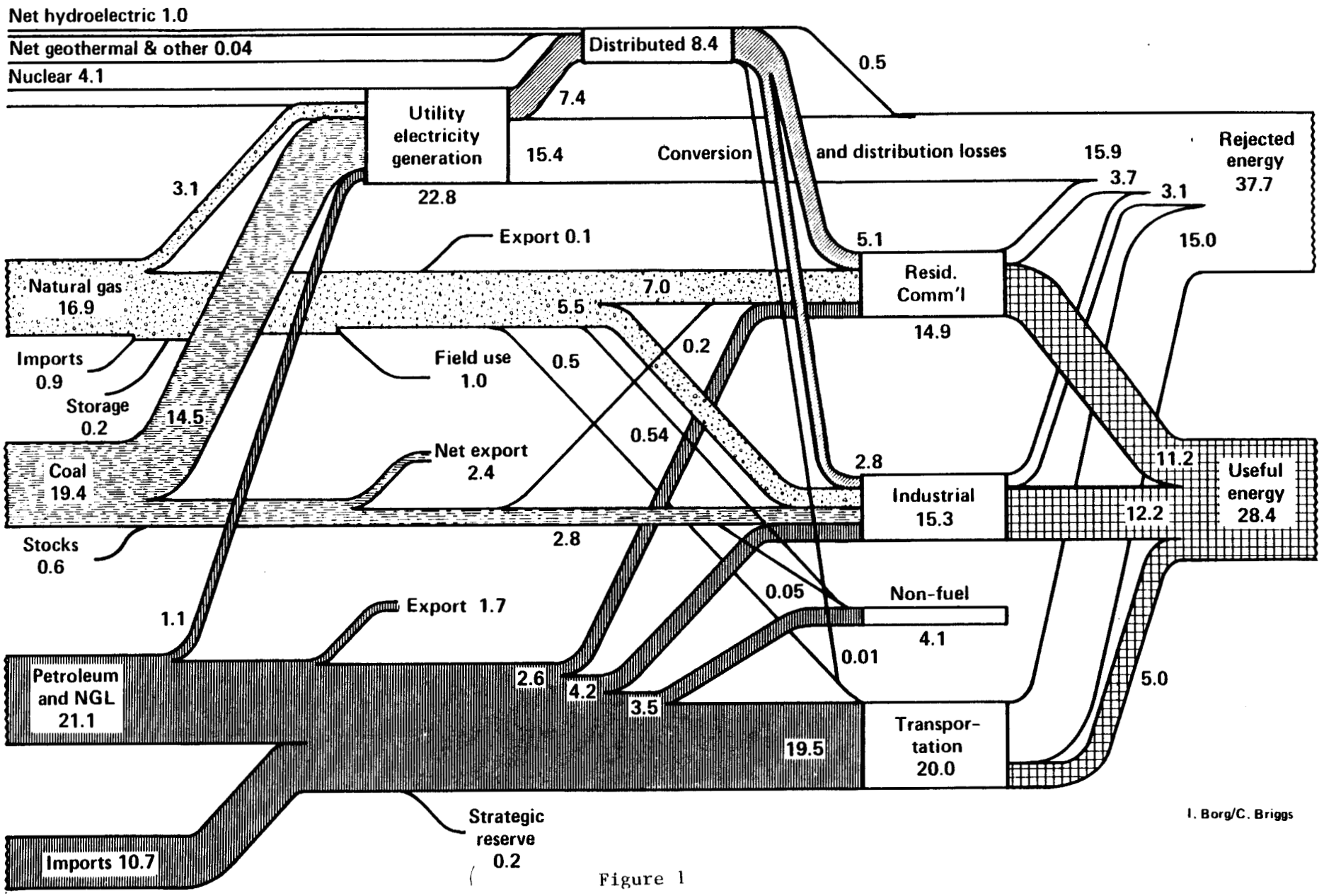

Figure 1

4
onsumption 73 Quads

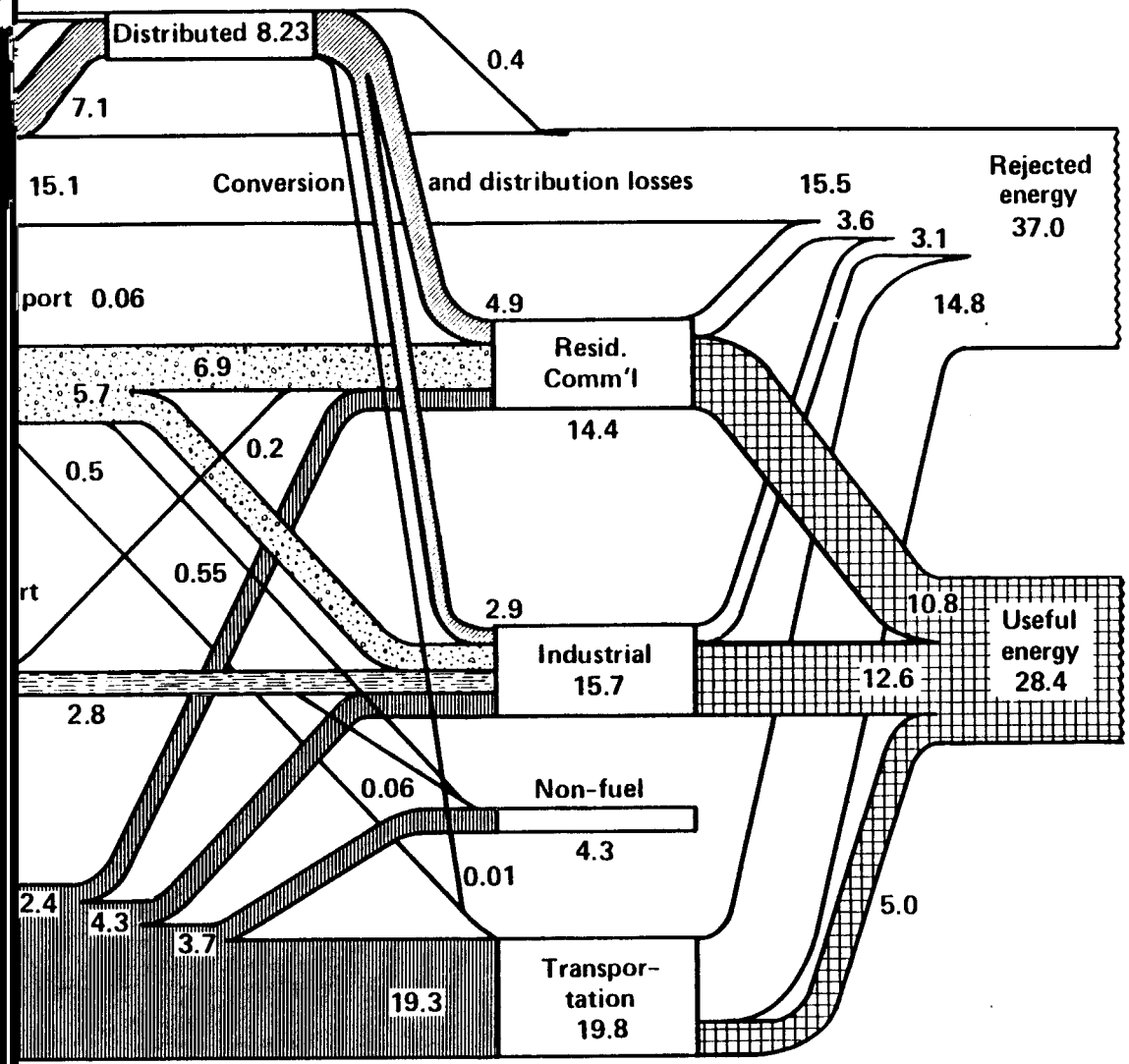

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Figure 2

TABLE 1. COMPARISON OF ANNUAL ENERGY USE IN U. S.[4]

	Quads						
	1979	1980	1981	1982	1983	1984	1985
Natural gas	20.08	19.91	19.70	18.26	16.34	17.75	16.89
Imports	1.25	0.99	.90	0.93	0.94	0.86	0.93
Crude oil and NGL							
Domestic crude & NGL	20.39	20.50	20.45	20.50	20.53	20.96	21.14
Foreign imports (incl. products & SPR)	17.90	14.63	12.69	10.82	10.56	11.39	10.68
Exports	1.00	1.15	1.26	1.73	1.56	1.53	1.65
SPR storage reserve*	0.14	0.10	0.71	0.37	0.49	0.42	0.24
Net use (minus exports and SPR)	37.15	33.89	31.17	29.22	29.04	30.40	29.93
Coal (incl. exports)	17.48	18.54	18.33	18.60	17.29	19.70	19.39
Electricity							
Hydroelectric (utility) (net only)	0.95	0.94	0.89	1.06	1.13	1.10	0.96
Geothermal & other (net only)	0.02	0.02	0.02	0.02	0.02	0.03	0.04
Nuclear	2.78	2.74	3.01	3.12	3.22	3.55	4.14
Gas	3.61	3.81	3.76	3.34	3.01	3.21	3.14
Coal	11.26	12.12	12.58	12.58	13.23	14.09	14.54
Oil	3.28	2.63	2.20	1.57	1.54	1.29	1.09
Total fuel	21.90	22.26	22.46	21.69	22.15	23.27	23.91
Total transmitted energy	7.67	7.80	7.83	7.65	7.88	8.23	8.43
Residential and Commercial	15.71	15.09	14.55	14.64	14.29	14.48	14.88
Industrial	25.53	23.79	22.50	19.98	19.55	21.11	20.37+
Transportation	20.44	19.67	19.47	19.04	18.97	19.81	19.98
Total consumption** (DOE/EIA)	79	76	74	71	70	73	74

* Strategic petroleum reserve storage began in October, 1977.

+ Includes field use of natural gas.

**Note that this total is not the sum of entries above.

TABLE 2 Percent of change from preceding year: (5)

(1982 dollars)	1984	1985
Gross National Product	6.5	2.3
Personal consumption expenditures	4.4	3.3
Gross private domestic investment	31.4	-1.9
Exports of goods and services	6.2	-2.9
Imports of goods and services	23.6	2.4
Government purchases of goods and services	4.3	5.9

COMPARISON WITH 1984 AND EARLIER YEARS

1985 U.S. energy consumption showed few significant changes from the previous year (Table 1). The greatest changes occurred in the primary energy sources used in the production of electricity. Due to low rainfall, hydroelectric generation fell. For the second year, the amount of net power generated from nuclear stations* exceeded that of hydroelectric power. Coal supplied 78% of all fossil fuels used for electrical generation, a 3% increase over 1984. Coal used to produce electricity represented 85% of the total U.S. coal consumption, which reached a record high level. A 2% drop in U.S. coal production was offset by the highest level of imports since 1979, 52% higher than in 1984. Withdrawal from stockpiles that were accumulated in 1984 as a precaution against a possible coal miner's strike contributed to 1985's domestic coal supply.

* Approximately 1.28Q based on 31% conversion efficiency

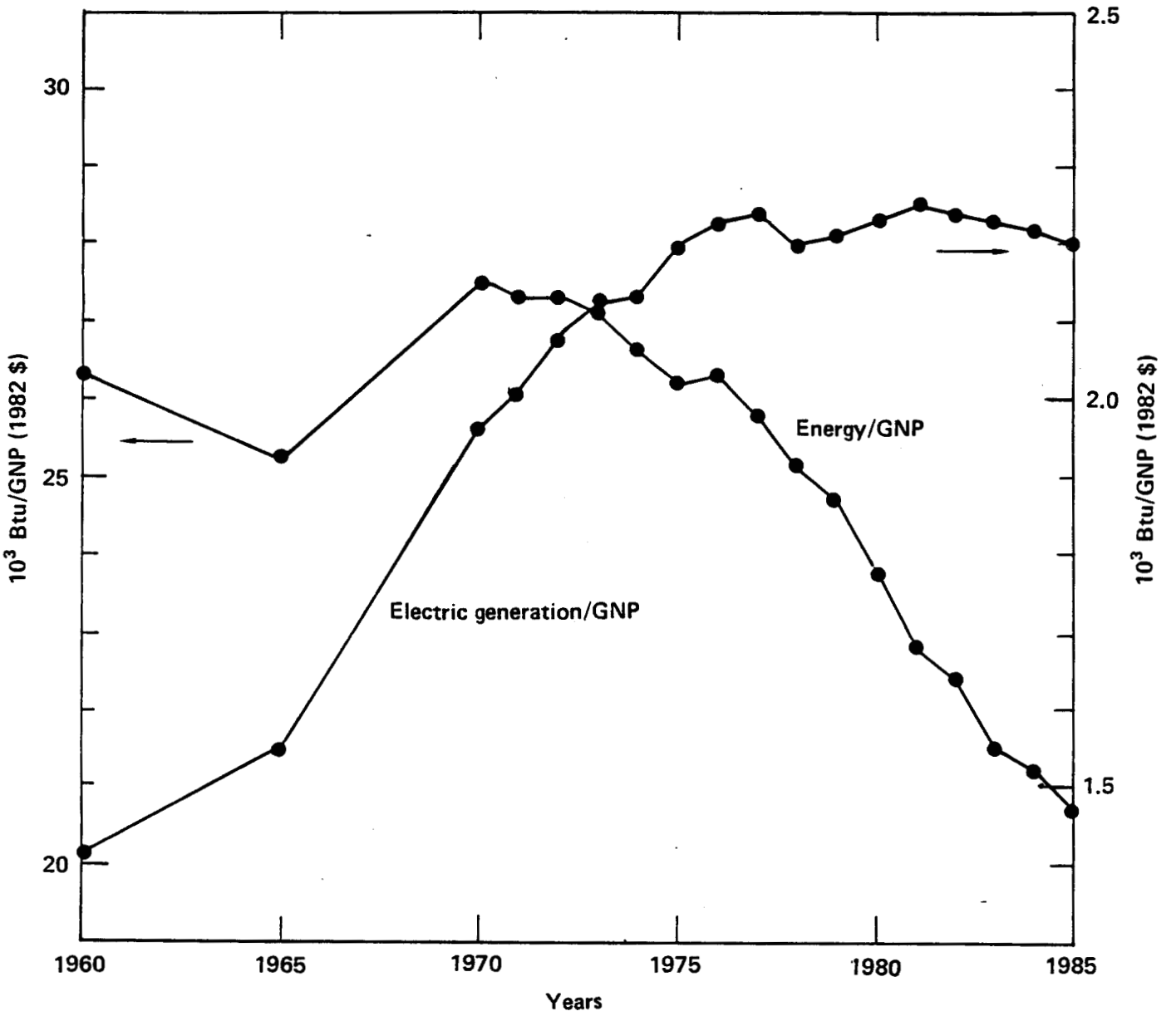

Figure 3. GNP related to energy use and electric generation.

Efficiency improvements, fuel switching and conservation restrained increase in petroleum usage, which changed very little. The average domestic wellhead price of crude oil dropped from $25.88/bbl to $24.08 while average landed cost of crude oil imports dropped from $28.42 to $26.72/bbl.[4] Net crude oil imports, shown in Fig. 4, fell 9%. A lower level of imports for the SPR and inventory drawdowns in anticipation of lower world oil prices both contributed to the decrease. Imports from Arab members of OPEC continued to drop while imports from Mexico and Canada increased so that by year-end, they collectively supplied 35% of net imports.

Domestic oil production (including crude oil, natural gas liquids and other hydrocarbons) rose for the fourth year in a row. Production decline at the super-giant Prudhoe Bay field on the North Slope, Alaska is now estimated to start in 1988. The 100-million barrel Milne Point field was connected to the Alaskan pipeline. Together with increased production at the Kuparak field, declines in production in the lower 48 states were more than offset by Alaskan increases. In response to falling prices, US drilling activity slowed dramatically as evidenced by the number of drill rigs operating. DOE estimates that 71,840 wells were drilled in 1985 versus a total of 76,620 in 1986.[7].

Despite talk of a natural gas bubble, overall natural gas use declined 4.3%; this drop was reflected in small decreases in electrical, residential and commercial, and industrial end-use sectors. Natural gas was partially decontrolled in January 1, 1985; about 40% remains under control. At the end of the year, wellhead prices had fallen 7% contrary to predictions of decontrol critics . The drop can in part be attributed to downward pressures on all types of energy following the collapse in oil prices.

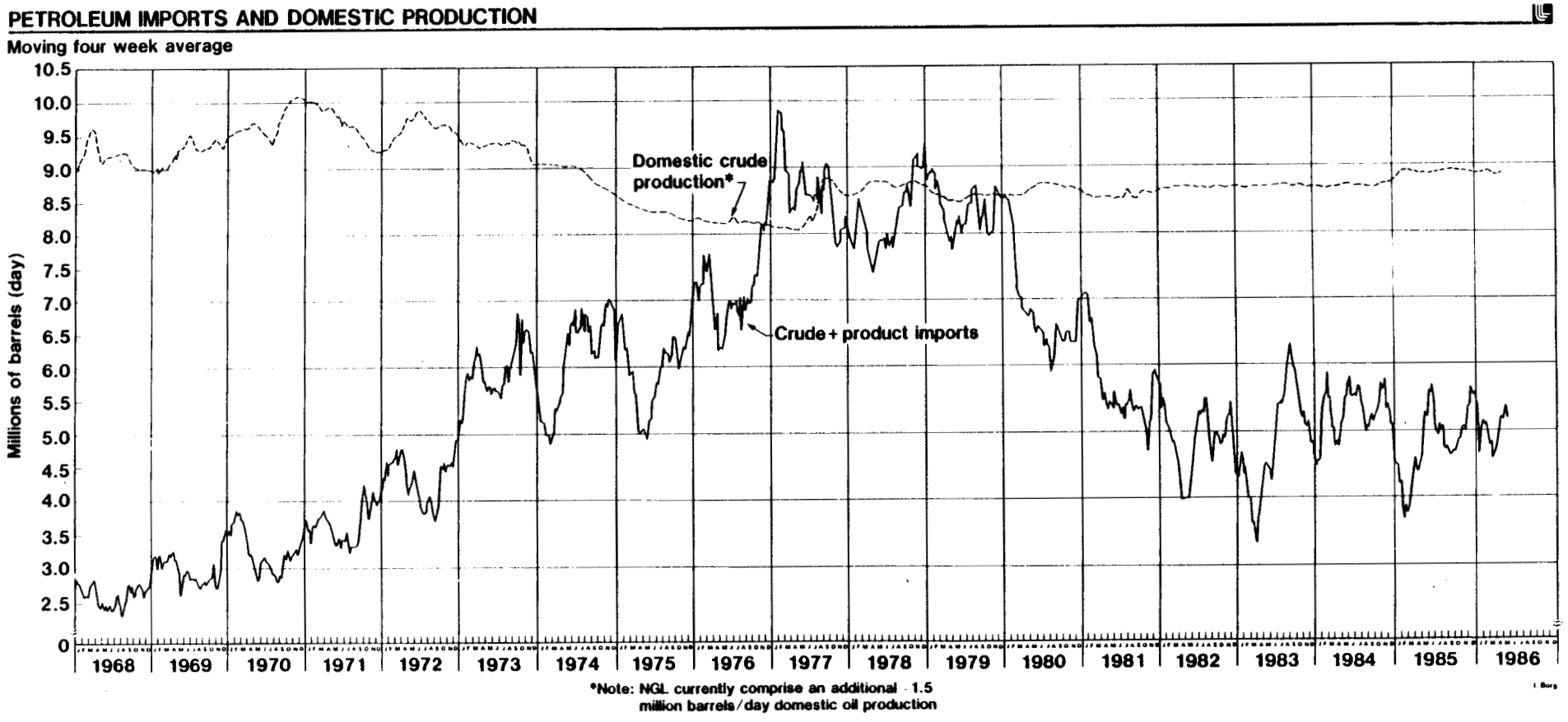
PETROLEUM IMPORTS AND DOMESTIC PRODUCTION
Moving four week average
Millions of barrels (day)
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
0
Domestic crude production*
Crude + product imports
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
*Note: NGL currently comprise an additional 1.5 million barrels/day domestic oil production

Figure 4

Useful energy totals for 1984 and 1985 were virtually the same (Figures 1 & 2). 1985's slight increase in rejected energy is attributed to higher utility electricity generation and transportation figures which represent less efficient processes in energy consumption.

Transportation accounted for 30% of all fossil fuels consumed and two-thirds of the petroleum supply. The amount of transportation fuels used has remained at 19-20 quads for a decade. An increase of 2% in motor gasoline use in 1985 (Table 3) reflects an increase in the number of autos and drivers and less emphasis on conservation of previous years. The average U.S. city retail price for all types of motor gasoline was 119.8 cents/gal in 1984 compared to 119.6 cents/gal in 1985.

1985 - THE STRATEGIC PETROLEUM RESERVE

Additions of 42 million barrels of oil to the Strategic Petroleum Reserve (SPR) in 1985 brought the total to 493 million barrels at year end. It is considered enough to replace more than 100 days of net imports to the U.S.; however it is questionable whether the amount could meet that goal in the next decade when imports are expected to increase. In the proposed budget for FY 1986, President Reagan called for a moratorium on further filling of the reserve and development of increased storage capacity. The objective is to reduce federal spending. Separate appropriation bills must be enacted each year to release funds, but Congress passed a bill requiring the stockpile to be filled to 500 million barrels by October 1986. A congressional budget resolution passed in early August 1985, provides that about $350 million be set aside annually for the next three years for strategic oil purchases. If the President approves the bill, the addition will probably be purchased from PEMEX, the Mexican national oil company. The last oil purchase for FY 1985 was one million barrels of North Sea crude from British Petroleum at $27.10 f.o.b. in late August.[8]

TABLE 3. PETROLEUM PRODUCTS.*

	10^3 Barrels/Day (Average)								
	1977	1978	1979	1980	1981	1982	1983	1984	1985
Motor gasoline	7177	7412	7034	6579	6588	6539	6622	6693	6815
Jet fuel	1039	1057	1076	1069	1011	1010	1050	1170	1190
Distillate fuel oil	3352	3432	3311	2866	2829	2671	2690	2845	2859
Residual fuel oil	3071	3023	2826	2508	2088	1716	1421	1369	1194

*Refined petroleum product supplied: sum of production, imports, net withdrawals from primary stocks minus exports.

Source: Monthly Energy Review, DOE/EIA-0035 (85/12)March 1986; 1985 Annual Energy Review, DOE/EIA-0384 (85) May 1986.

NUCLEAR POWER IN 1985

Nuclear power continued to grow in the U.S. It produced almost 16% of electric power in 1985 (Table 4). As of year-end 130 plants were in operation, had construction permits or on order. Design capacity of the 130 is 121 GW_e.

Table 4 Electrical Generation

	1984	1985
Total electrical generation (bn kwh)	2416	2469
Nuclear contribution (bn kwh)	328	384
Percent nuclear	13.6%	15.5%
Installed nuclear capacity (GWe)	69.5	78
Number of operable reactors	86	95*
Annual capacity factor	56.5%	58.5%

* An additional 3 reactors are in start-up status

During 1985 the Nuclear Regulatory Commission granted full power licenses to 9 nuclear generating units,* and eight units were declared commercially operable.** Marble Hill - 1 & 2 units were cancelled. Of the 95 operable reactors five were in power ascension and 23 units generated no electricity or amounts substantially below capacity. The Nuclear Regulatory Commission (NRC) issued licenses authorizing fuel-loading and low power testing to Millstone-3, Palo Verde-2 and Shoreham.

* Catawba-1, Byron-1, Waterford-3, Palo Verde-1, Wolf Creek, Fermi-2, Limerick-1, Diablo Canyon-2 and River Bend-1.

** Susquehanna-2, Callaway-1, Diablo Canyon-2, Catawba-1, Grand Gulf-1, Byron-1, Wolf Creek-1 and Waterford-3.

Status of Problem-Plagued Nuclear Projects and Plants

Shoreham

None of the outstanding issues impeding full power license at Shoreham affect low power operation. The key issue at Long Island Lighting Co's (Lilco) Shoreham nuclear plant (809 MWe) in Suffolk County, is emergency planning. A New York state court issued a ruling that prevented Lilco from implementing its proposed emergency evacuation plan for the Shoreham plant.(9).

San Onfre

San Onfre 1 (436 MWe) on California Coast near San Luis Obispo, down since early 1982 for seismic upgrading, was given permission for full power operation in November 1984. On November 21, 1985 an accident at San Onofre 1 involved both a loss of electrical power and a leak in the main feedwater system. The plant was at 60% power when an electrical transformer malfunctioned, tripping the reactor. Back-up diesels started but failed to connect to the electrical busses that carry power to the plant. It took 10-15 minutes to restore power. At the time of the accident, the utility also discovered a leak in the main feedwater line which provides water to the steam generator. The plant was in cold shutdown after the accident awaiting the report of the NRC team sent from Washington to look into the incident.(10)

Fort St. Vrain

After 13 months closure, Public Service CO. of Colorado's St. Vrain nuclear plant received federal approval in July to start its reactor. Closure was due to the discovery of moisture in the helium used to cool the plant's radioactive core and failure of six of the plant's 37 control rods to insert automatically.(11)

Seabrook

Seabrook nuclear power plant in Seabrook, N.H. started as a twin unit. As costs escalated out of control, Unit 2 was conditionally canceled and funding has been difficult for the original unit.(12) Experts promoting completion of the project cite the urgent need for power to keep New England's economy strong. As of May 1985, the reactor was 86% completed and 5 years behind schedule. The State Supreme Court permitted resumption October 1, 1985 of full construction on Seabrook 1.(13) As a result of escalating costs and delays, three Maine utilities and one Vermont utility were told by their regulators to sell their shares in the project. The final sales transaction for Seabrook-1 has been extended to June 30, 1986. The projected commercial operation date for the 1150 MWe plant is October 1986.(14)

Zimmer

Columbus, Southern Ohio Electric Company, Cincinnati Gas and Electric Company and Dayton Power and Light Company, owners of what was originally to be Zimmer nuclear plant in Moscow, Ohio, proposed in Jan. 1984 conversion from nuclear to coal fired operation. Final decision on carrying out the conversion is expected in 1986. The owners were forced to take large writeoffs against 1985 earnings for their investments in the abandoned nuclear power plant.(15)

Midland

Midland Nuclear power plant in Jackson, Michigan, was 85% complete at an expense of $4 billion when work stopped in July 1984 as a result of construction, regulation and financing problems. Consumers Power Co., Midland's owner, is considering requesting permission to convert the nuclear plant to a gas fueled generator.(16)

Three Mile Island

On October 8, 1985, the Nuclear Regulatory Agency granted approval to Three Mile Island Unit I to increase power output to the level necessary to begin generating electricity. General Public Utilities had completed tests at 3% power. Full 800 MWe will be reached in three months after two month long holds, at 48% and 75% power, to allow additional training of six shifts of operators.(17)

1985 - A TURNING POINT?

In most respects, energy supply and demand were similar in 1984 and 1985. A slight decline in GNP growth was associated with an appreciable drop in farm income. Energy use per unit GNP (in constant dollars) fell for the thirteenth year reflecting the increasing contribution of services as opposed to industrial activity to the GNP. Total transmitted electrical energy increased in 1985 with increases in both nuclear and coal contributions. At year-end crude oil prices fell; however growth in the transportation end-use sector in 1985 must be attributed to other factors. From all indications price driven conservation that has made in-roads into consumption in major end-use sectors will not continue at the same level into 1986. 1985 may represent a turning point in the decline in U.S. energy use since the disruptive events associated with the 1978 Iranian revolution.

Appendix

Data and Conventions Used in Construction of Energy Flow Charts

Data for the flow chart were provided by tables in the Department of Energy Monthly Energy Review, DOE/EIA-0035[4], the 1985 Annual Energy Review [18] and the Quarterly Coal Report, DOE/EIA-0121.[19]

The residential and commercial sector consists of housing units, non-manufacturing business establishments, health and education institutions, and government office buildings. The industrial sector is made up of construction, manufacturing, agriculture, and mining establishments. The transportation sector combines private and public passenger and freight transportation and government transportation including military operations.

Utility electricity generation includes power sold by both privately and publicly owned companies. The non-fuel category of end-use consists of fuels that are not burned to produce heat, e.g., asphalt, road oil, petrochemical feedstocks such as ethane, liquid petroleum gases, lubricants, petroleum coke, waxes, carbon black and crude tar. Coking coal traditionally is not included.

The division between "useful" and "rejected" energy is arbitrary and depends on assumed efficiencies of conversion processes. In the residential and commercial end-use sectors, a 75 percent efficiency was assumed which is a weighted average between space heating at approximately 60 percent and electrical lighting and other electrical uses at about 90 percent. Eighty percent efficiency was assumed in the industrial end-use sector and 25 percent in transportation. The latter percent corresponds to the approximate efficiency of the internal combustion engine.

There are some minor differences between total energy consumption shown here in the energy flow charts and the DOE/EIA totals given in Table 1. We use net hydroelectric power in flow charts rather than the gross amount, which is customarily included in DOE/EIA totals. The net figure is calculated from the total number of kilowatt hours produced by hydroelectric sources. Thus the sum of individual contributions to annual energy consumption shown in the energy flow charts will be smaller by several quads (10^{15}btu) than total published by DOE/EIA and given at the top of the chart and in Table 1.

Conversion Factors

The energy content of fuels varies. Some approximate, rounded conversion factors, useful for estimation, are given below.

Fuel	Energy Content (Btu)
Short ton of coal	22,400,000
[redacted]	[redacted]

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