Mines Branch Information Circular IC 236

INDIVIDUAL CONSUMPTION AND UTILIZATION OF ENERGY IN CANADA, U.S.A., BRITAIN, FRANCE, GERMANY AND SWEDEN, 1950-1965

by

R. P. Charbonnier[1]

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ABSTRACT

Eleven graphs present, for Canada and five other comparable countries, the trends of their per-capita consumption of total energy, hydro-electricity, and separately: liquid, solid and gas fuels, and of their per-capita energy utilization (usable consumption based on estimated conversion efficiencies).

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[1]Chief Scientist (Programs), Metals Reduction and Energy Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

Direction des mines

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CONSOMMATION ET UTILISATION INDIVIDUELLES D'ÉNERGIE AU CANADA, AUX ÉTATS-UNIS D'AMERIQUE, EN GRANDE BRETAGNE, EN FRANCE, EN ALLEMAGNE ET EN SUÈDE, 1950-1965

par

R. P. Charbonnier[1]

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RÉSUMÉ

Onze graphiques présentent, pour le Canada et cinq autres pays comparables, les tendances de leur consommation per-capita d'énergie totale, d'hydro-électricité, et séparément: de combustibles liquides, solides et gazeux, ainsi que de leur utilisation d'énergie per-capita (consommation utile basée sur des estimations des efficacités de conversion).

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[1]Scientifique principal (Programmes), Centre d'énergie et de réduction des metaux, Direction des mines, ministère de l'Énergie, des Mines et des Ressources, Ottawa, Canada.

TRENDS IN THE INDIVIDUAL CONSUMPTION OF ENERGY IN SIX SELECTED COUNTRIES

In order to compare the industrialization progress in various countries, their energy consumption and population data have been obtained from a number of United Nations publications,(1) and processed to find comparable indices of unitary consumption of the main energy sources. Although the comparison of countries in various stages of development was interesting, this study will be limited to six selected countries, generally considered as having reached a mature stage of industrial development and without general overpopulation problems. These countries are in addition to Canada: the United States of America, Great Britain, France, Western Germany and Sweden. The data under consideration here were supplied to the United Nations statistics offices by the governments of each country for the years 1950 to 1965.

Figure 1 shows the variations of estimated per-capita energy consumption in total Btu calorific contents of the main energy resources used in these countries from 1950 to 1965. For comparisons of energy facilities at the disposal of individual citizens, these data have been computed on a per-capita basis. However some citizens often use the same energy, e.g., children with their parents, old people living together; therefore instead of "per capita", another type of basis could be preferable, e.g., "per family". This would be important if some of the countries being compared had very different population group distributions, e.g., developing countries with large families in comparison to industrialized countries with small families. Such is not the case in this study.

Since the various sources of energy are used in different proportions in the countries under study, the main components of the total energy consumption data were shown separately in Btu calorific contents, as follows: Figure 2 represents the variations of per-capita consumption of liquid fuels (mainly oil products). It is clear that Canada and Sweden are quickly approaching the United States in this regard, although they were far below

even as recently as a decade ago. On the other hand, Britain, France and W. Germany, in spite of large relative increases of their individual consumption, were reaching in 1965 a level only 50 per cent as high as that of the first three countries named above. This may be due in part to higher climate and transportation requirements, which could explain some permanent differences between groups of countries.

Figure 3 shows the trends in per-capita consumption of solid fuels (mainly coal products). The wide differences in consumption levels among the six countries under study may be explained by differences in the availability of coal within their borders and in the unemployment problems of their coal industries. The general consumption trend is downward with definite signs of recovery and upturn in the U.S.A. and to a lesser extent in Canada, where the decline of coal consumption had been most severe after 1950, when the per-capita consumption was similar in Canada, W. Germany and the U.S.A. The apparent stability of consumption for France is actually a decline relative to the other energy sources.

Figure 4 illustrates the variations in per-capita consumption of hydro-electricity. Britain and Germany were omitted because their consumptions were very low. The Canadian consumption has increased at a high rate from an already high level, but the Swedish consumption rise was even faster and finally caught up with the Canadian level in 1965. At a much lower level, France and the United States have had a slight increase. These differences in consumption levels are mainly due to the differences in availability of remaining hydro-sites in these six countries.

Figure 5 shows the trends in per-capita gas consumption (mainly natural gas). Starting from a much lower level than the U.S.A., Canada has increased even faster and the consumption gap between them seems to be closing. On the other hand France and W. Germany remain at a relatively low level, while Britain and Sweden do not appear on the Figure, although the future is brighter especially for Britain.

TRENDS IN THE INDIVIDUAL UTILIZATION OF ENERGY

It is interesting to compare the trends in consumption of the main energy sources in each country, as shown for Canada in Figure 6, where the curves corresponding to Canada in Figures 2, 3, 4 and 5 have been reproduced together to illustrate the variations of Btu energy consumption per-capita in Canada for the main sources of energy according to their calorific contents. The concomitant decline of solid fuels and rise of liquid and gaseous fuels are better indicated in relative values in Figure 7, which shows the various proportions of energy supplied by the main sources of energy. While the share of hydro-electricity has remained approximately constant, solid fuels supplied in 1965 only one third as much gross calorific content as in 1950, whereas liquid fuels increased by 50 per cent, and the gas share was multiplied seven times.

Figures 6 and 7 allow comparisons of the principal energy sources in Canada[2] according to their calorific content for fossil fuels, and the thermal equivalent for hydro-electricity. This usual conventional type of energy conversion unfortunately shows gas and, even to a high degree, hydro-electricity as far less important than they really are as sources of energy, because of the considerable differences in conversion efficiencies of calorific contents into usable energy for the various energy sources[3]. Table 1 gives estimated assumptions of average conversion efficiencies in Canada[4]; the figures conventionally used for calorific contents are less open to argument. However many assumptions and estimates must be made of the calorific contents of the various fuels included in the available statistical data, where the quantities of different fuels are often added together, for instance, bituminous and sub-bituminous coals with different calorific contents.

Ultimate utilization efficiencies vary considerably within each category of energy source depending on the type of conversion equipment used and on local conditions. For instance for coal, the efficiency may usually range from 40 to 60 per cent in furnaces, and from 25 to 35 per cent in steam plants for power generation; for oil, the efficiency may range from 60 to 65

per cent in furnaces, from 15 to 40 per cent in engines for transportation and from 25 to 35 per cent in steam plants for power generation; for natural gas, the efficiency may range from 70 to 75 per cent in furnaces, from 20 to 30 per cent in gas turbines, and from 30 to 35 per cent in steam plants with gas and steam turbines. Weighted averages were obtained by estimating the quantities of each energy source used for a given type of conversion. Although these estimates are only approximative, it is better for comparisons to try to approach the physical realities of inefficient conversions rather than to use more accurate but unreal data based on Btu contents, of which only varying fractions are ultimately available as usable energy.

Figure 8 shows for Canada the trends in usable energy per-capita consumption based on the assumed efficiencies given in Table 1. The very sharp increase in energy obtained from gas between 1950 and 1965 is now obvious. The dominant position of gas and to a lesser extent of hydro-electricity is in evidence, whereas Figure 6 is somewhat misleading in this regard. The relative importance of each energy source is even more in evidence in Figure 9, which shows the proportions of each energy source in the total usable energy consumption for Canada. The declining position of hydro-electricity and liquid fuels is now clear. Finally Figure 10 gives average annual per-capita increases or decreases in usable-energy consumption from the various sources at five-year intervals, in order to emphasize the different trends.

The preceding analysis of the Canadian data has been applied to the other five countries previously considered: the U.S.A., Britain, France, W. Germany and Sweden. The results of this study are summarized in Figure 11, which shows the variations in estimated per-capita energy utilization in total kwh for each country on the basis of the assumed average efficiencies for the various energy sources.

RPC/gf

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(1) "World Energy Supplies", Statistical Papers, Series J, No. 1 to 10, United Nations, New York.

(2) R.P. Charbonnier, C.E. Baltzer, R.A. Simpson; "Comparative Position of the Main Fuels in Canada", World Power Conference, Tokyo, October 1966, Paper 11B 106.

(3) G.A. Vissac, R.P. Charbonnier; "Comparison of Canadian Energy Prospects", Engineering Journal of the Engineering Institute of Canada, April 1964.

(4) R.P. Charbonnier, W.H. Harper; "Trends in Per Capita Consumption of Energy in Canada", Divisional Report FRC 67/104, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, September 1967.

TABLE 1

Energy Source	Estimated weighted-average conversion efficiency from calorific content to usable energy in Canada.	
	Approximate Percentage	Assumed number of input Btu energy required per kwh of output energy (mechanical or heat)
Solid Fuels	45%	8,000 Btu/kwh
Liquid Fuels	35%	10,000 Btu/kwh
Gaseous Fuels	70%	5,000 Btu/kwh
Hydro-electricity	90%	4,000 Btu/kwh

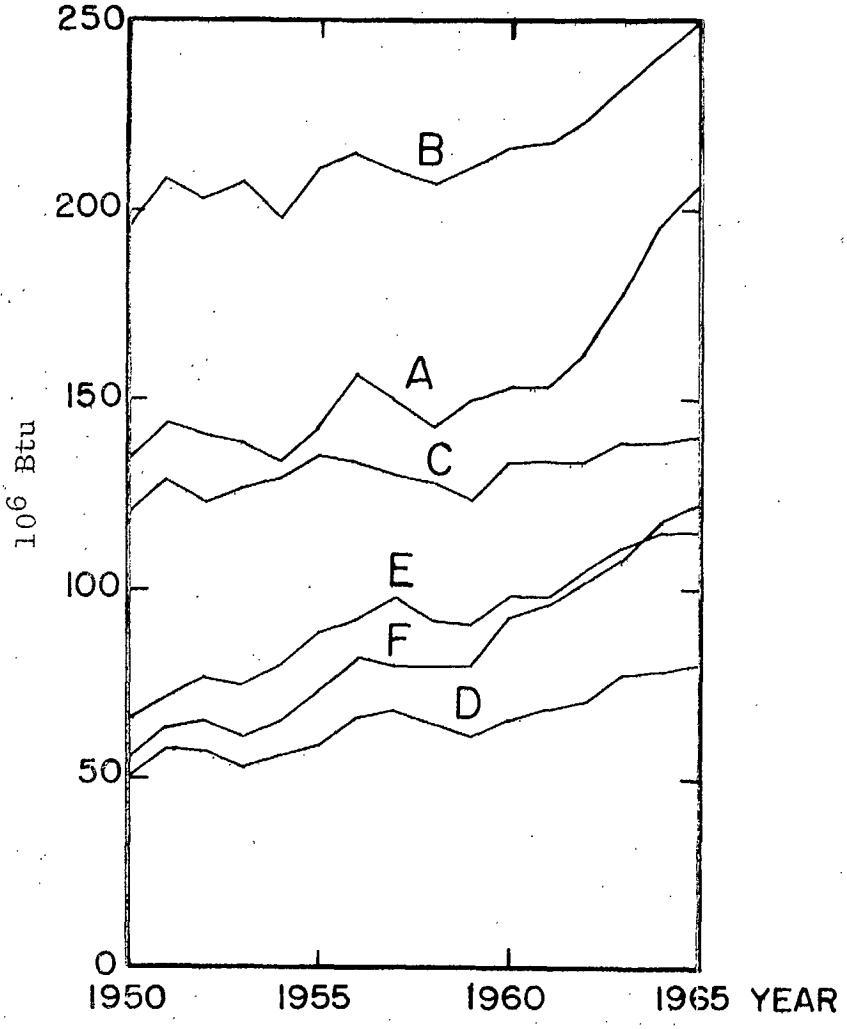

FIGURE 1

Estimated Per-Capita Energy Consumption
of the Main Energy Resources

A. Canada
B. United States
C. United Kingdom
D. France
E. Germany
F. Sweden

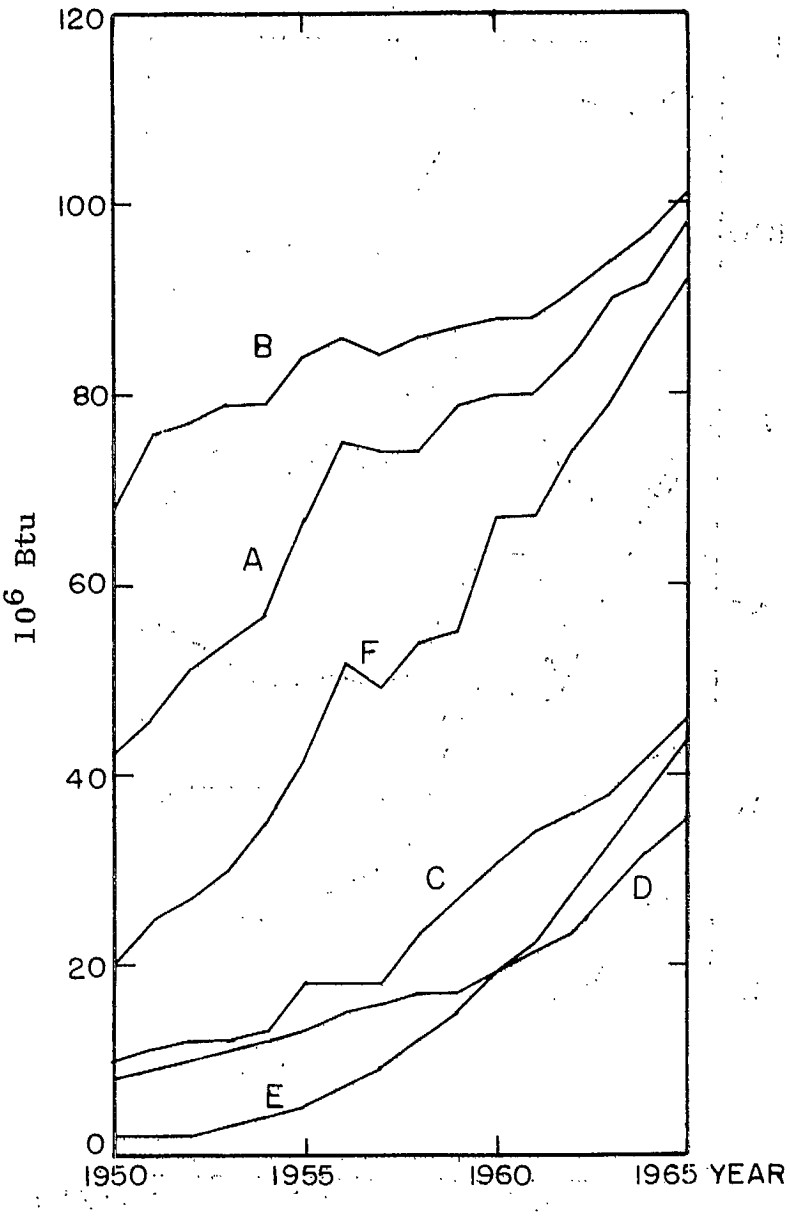

FIGURE 2

Liquid Fuels - Btu Energy Consumption Per-Capita

A. Canada	D. France
B. United States	E. Germany
C. United Kingdom	F. Sweden

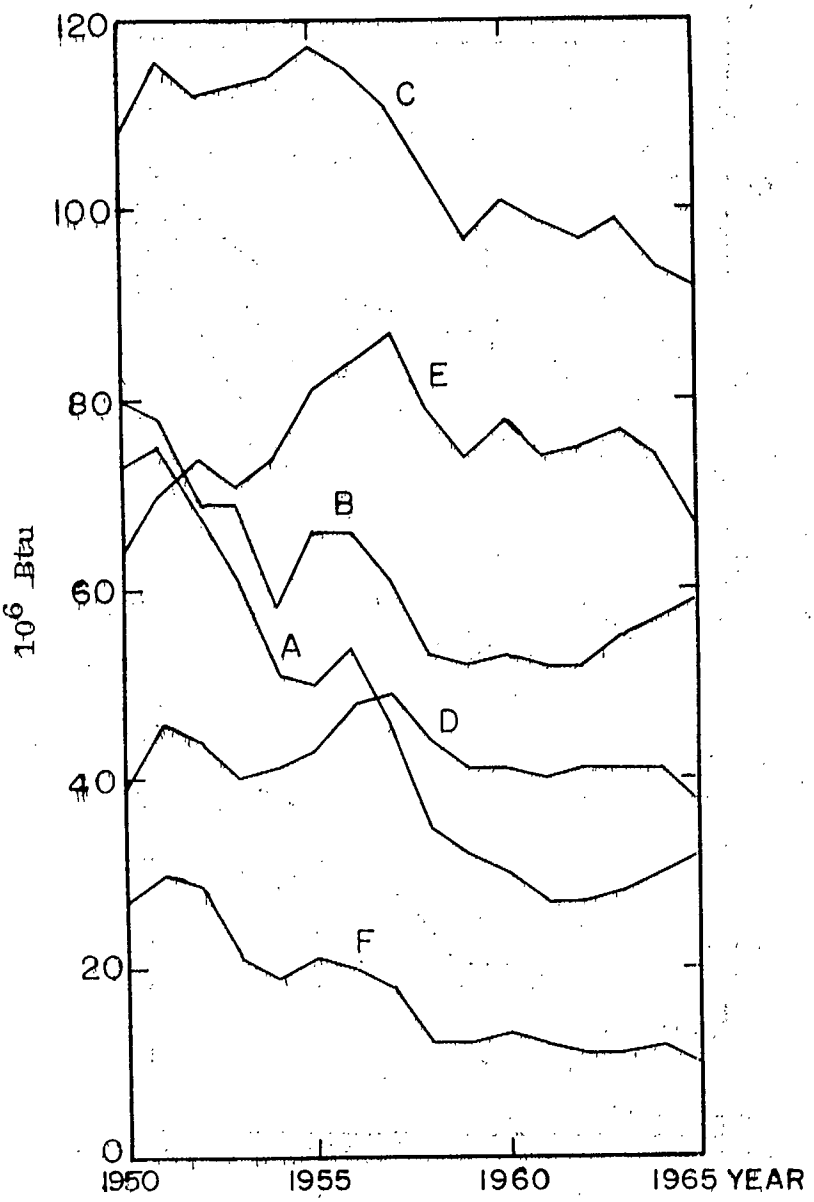

FIGURE 3

Solid Fuels -
Btu Energy Consumption
Per-Capita

A. Canada
B. United States
C. United Kingdom
D. France
E. Germany
F. Sweden

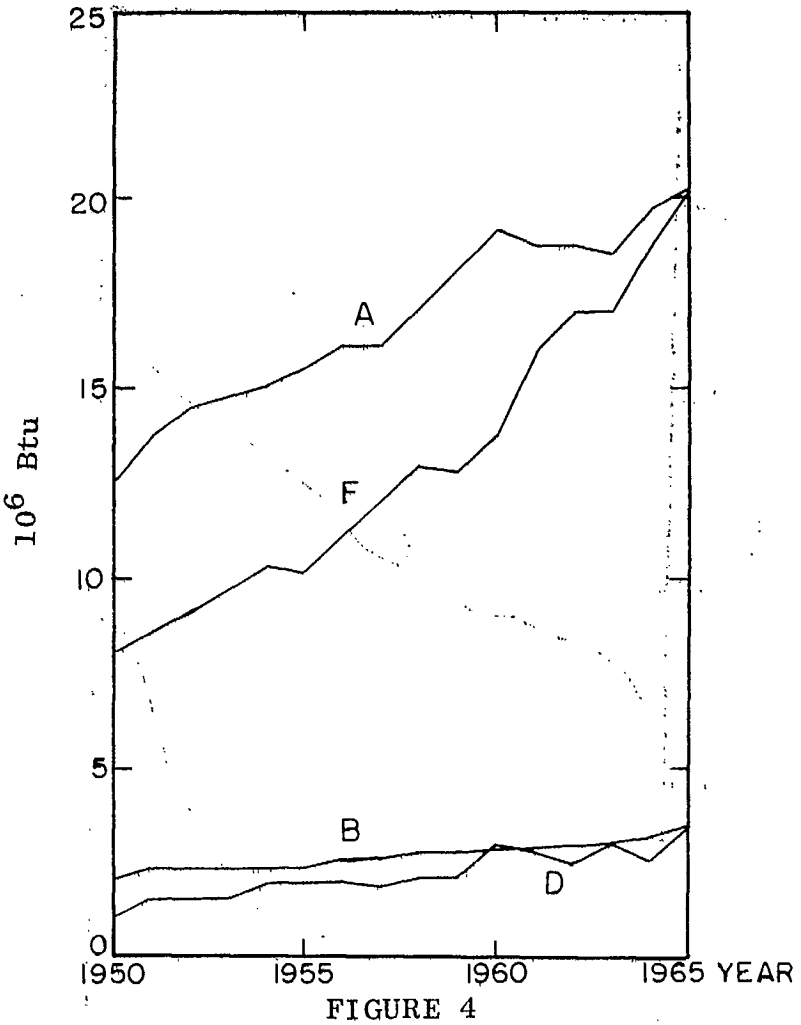

FIGURE 4

Hydro-Electricity -
Btu Energy Consumption
Per-Capita

A. Canada
B. United States
C. United Kingdom
D. France
E. Germany
F. Sweden

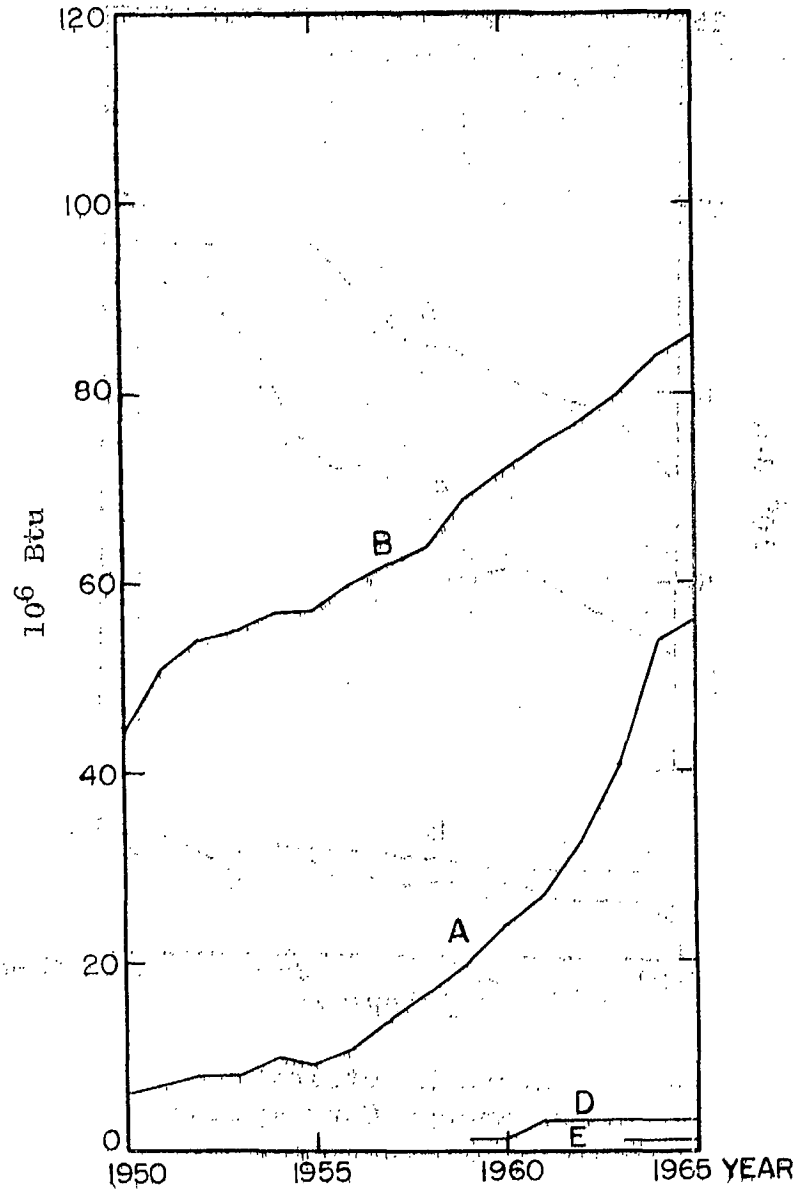

FIGURE 5

Gas - Btu Energy Consumption Per-Capita

A.	Canada	D.	France
B.	United States	E.	Germany
C.	United Kingdom	F.	Sweden

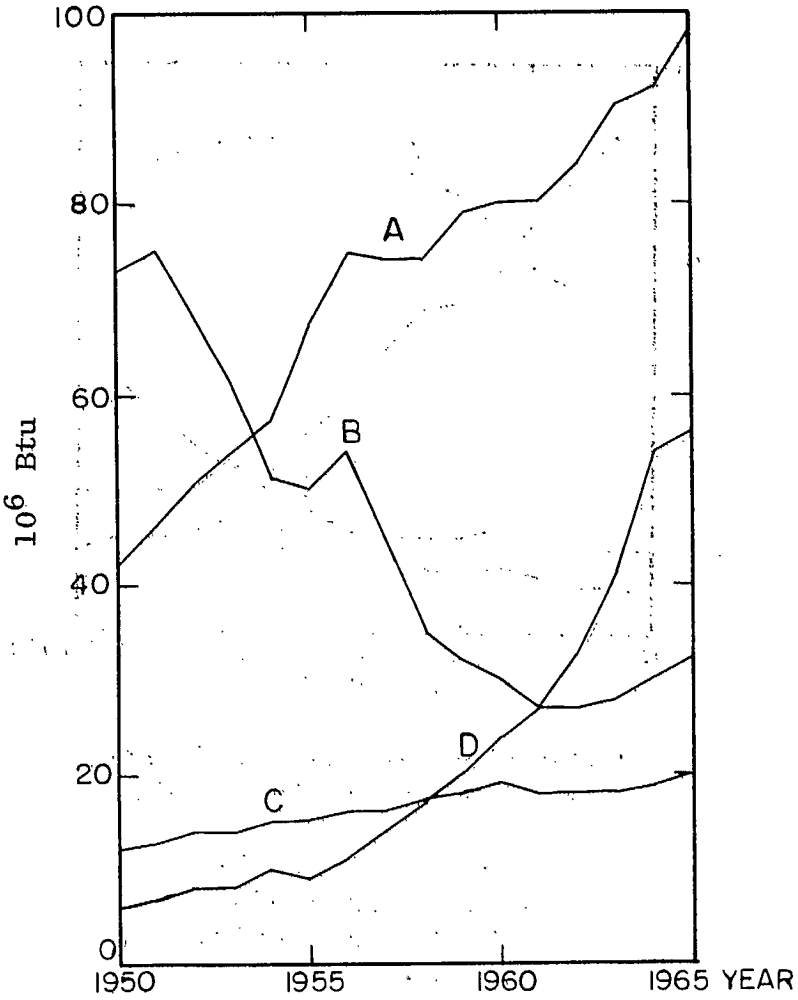

FIGURE 6

Btu Energy Consumption
Per-Capita in Canada

A. Liquid Fuels
B. Solid Fuels
C. Hydro Electricity
D. Gas

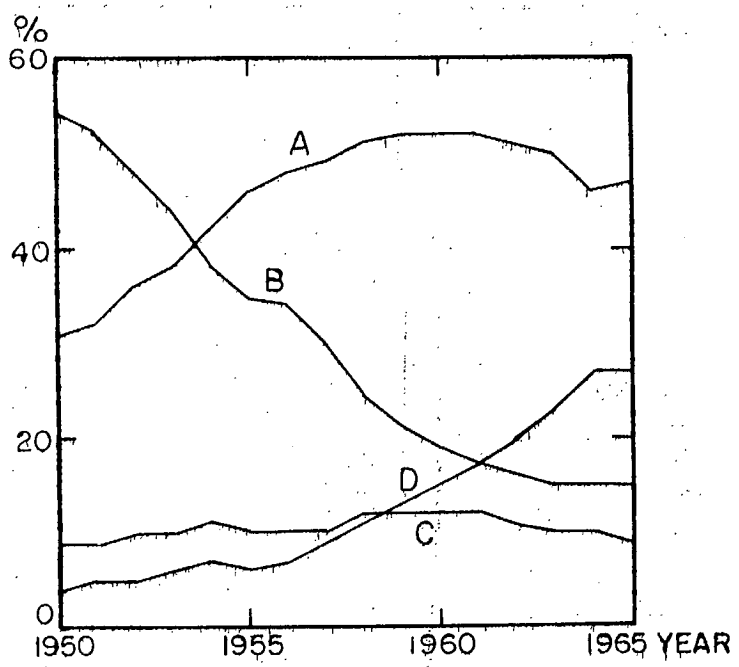

FIGURE 7

Proportions of Energy Sources
in Consumption in Canada

A. Liquid Fuels
B. Solid Fuels
C. Hydro Electricity
D. Gas

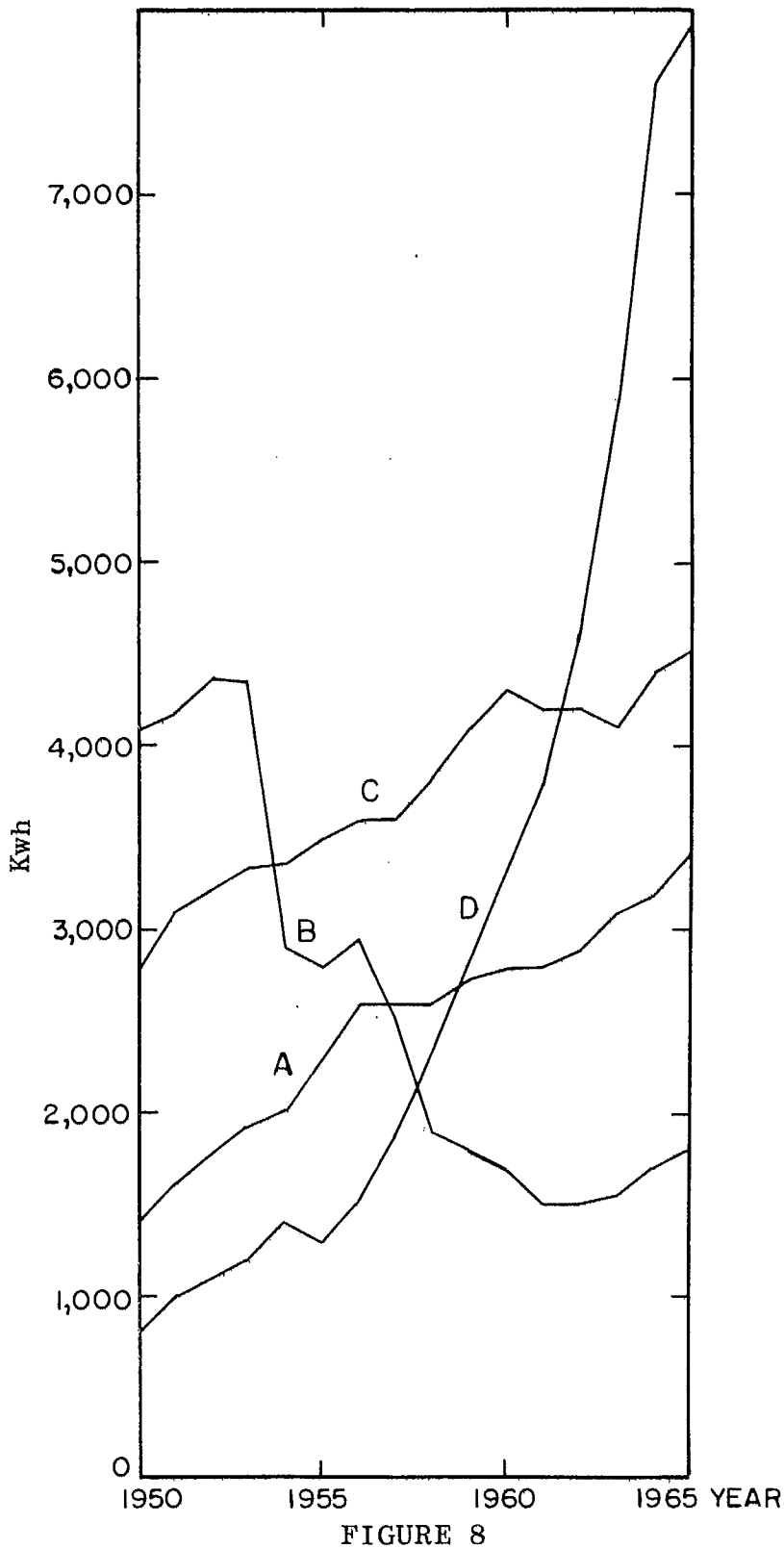

FIGURE 8

Usable-Energy Consumption
Per-Capita in Canada
Based on Assumed Efficiencies

A. Liquid Fuels
B. Solid Fuels
C. Hydro Electricity
D. Gas

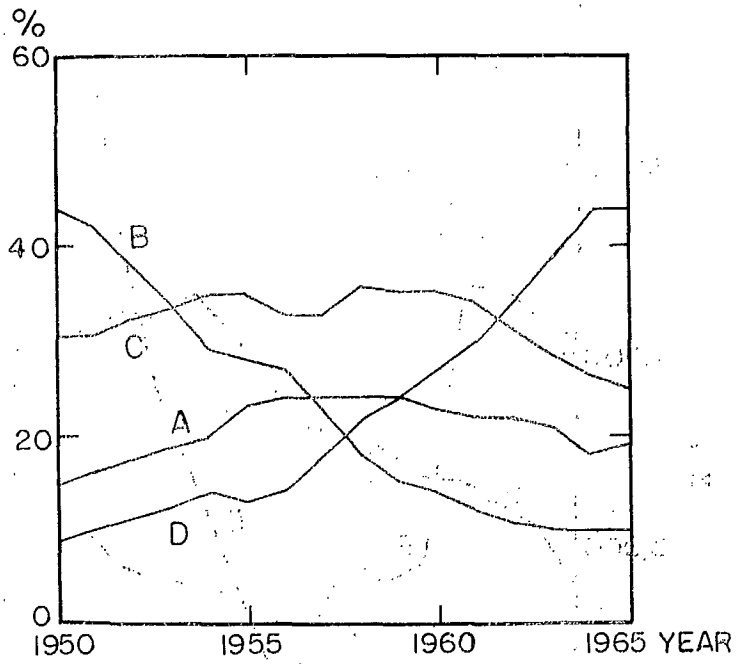

FIGURE 9

Proportion of each Energy Source in the Usable-Energy (kwh) Consumption in Canada

A. Liquid Fuels
B. Solid Fuels
C. Hydro Electricity
D. Gas

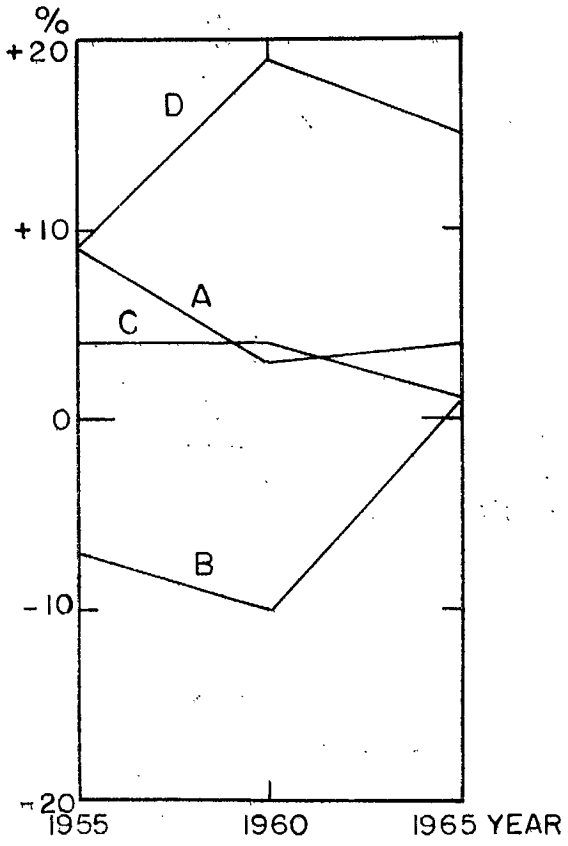

FIGURE 10

Average Annual Per-Capita
Increase or Decrease of
Usable-Energy (kwh) Consumption
During Previous Five Year
Period in Canada

A. Liquid Fuels
B. Solid Fuels
C. Hydro Electricity
D. Gas

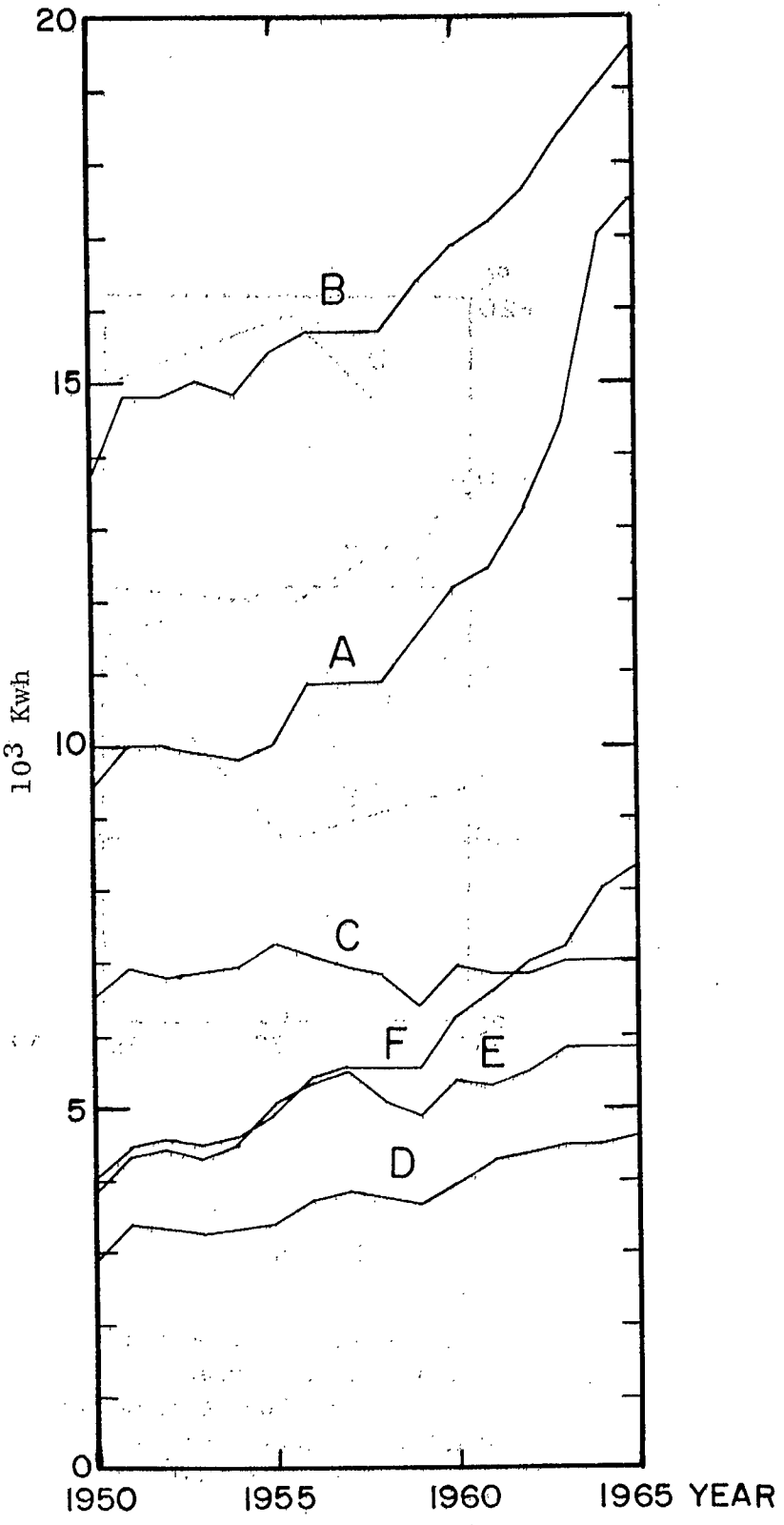

FIGURE 11

Estimated Per-Capita Energy Utilization on the Basis of the Assumed Average Efficiencies for the Various Energy Sources

A. Canada
B. United States
C. United Kingdom
D. France
E. Germany
F. Sweden