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ENERGY DEMAND BY US MANUFACTURING INDUSTRIES

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PREFACE

This article is concerned with the US manufacturing industries' energy demand, output, and coefficients of energy used per value of output observed since 1947 and some projections thereof up to the year 2000. The brief description of the variables is designed to help in the understanding and comparison of the amounts of energy used per unit of output that serve as an indicator of the efficiency with which energy is used in the manufacturing sector.

The purpose of the exercise was to provide a data basis for the energy demand models MUSE and MEDEE, which are part of the global energy demand modeling effort[1] of IIASA's Energy Systems Program. Another purpose was to evaluate the conclusions reached on industry's future demand for energy.

These conclusions may be implicit rather than explicit. For instance, will the "energy consumed per value added" continue its historic decline to 1985 (all estimates seem to agree), and can this trend be expected to continue from 1985 to 2000? Perhaps yes, according to WAES final energy demand estimates in *Energy Supply-Demand Integrations to the Year 2000*, but not so according to the Brookhaven *Analysis of Past and Expected Future Trends in US Energy Consumption, 1947-2000*, which shows a reversal of the trend after 1985. Some of this apparent discrepancy may be explained by the fact that the Brookhaven study envisaged the manufacturing industries' demand for primary energy, under the impact of the rising trend in electrification, whereas the WAES study looked at final energy.

A review of the five energy-intensive industries, which together constitute about 80 percent of the manufacturing sector's energy demand (excluding petroleum and coal products that are part of the energy sector), may provide a clue on the future shape of energy consumption by industry. This future is looked at not only in the light of the historical period; the paper also takes into consideration the very last statistics for the years 1974-1976, which were released only after most of the projections currently available had been formulated. Thus the analysis provides a means of testing the basis of those projections.

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[1] MUSE is a scenario-oriented model which explicitly treats parameters of lifestyle, technology, economy, and end-use efficiency; it was developed and implemented at IIASA. See the forthcoming IIASA publication by J.-M. Beaujean, *MUSE: A prospective Model for the Long-Range Evaluation of Useful Energy Demand.* The MEDEE model, developed at the Institut Economique et Juridique (IEJE) of the Grenoble University was implemented in a simplified version at IIASA. See the forthcoming IIASA publication by Bruno Lapillonne: *The MEDEE Model for Long-Term Energy Demand Forecasting.*

ABSTRACT

The paper intends to analyze the US manufacturing industries' demand for energy, total and per value added, over the last 25 years with an outlook into the future. The study concentrates on 5 energy-intensive industries (food, paper, chemicals, stone and clay, metals), which together absorb about 80 percent of the total energy consumed in manufacturing industries, excluding coal and petroleum products. The historical growth rates of the last 25 years show for each of these industries and total manufacturing a decrease in the amount of energy used per unit of output. This trend was observed during the periods of economic growth, when energy was relatively cheap and abundant; and it continued during the recent past in the 1975/76 recession. The question is raised of how various research bodies see the development of these trends in their projections up to the year 2000.

The study which contains detailed data on methods and sources for various concepts of energy consumption and manufacturing output, was originally used to provide the data basis for the IIASA modeling exercises of energy demand by manufacturing industries.

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CONCEPTS

The Statistical Universe

In order to avoid confusion between manufacturing and industry, it should be kept in mind that industry or the industrial sector consists of manufacturing and nonmanufacturing industries. In the following we are concerned only with the manufacturing industries, excluding petroleum refining and coal processing. In terms of the US standard industrial classification (SIC) this comprises Major Groups 20 to 39, excluding SIC Group 29 Petroleum Refining and Coal Products[1]. In terms of the United Nations Standard Industrial Classification this corresponds to ISIC Division Three excluding groups 353 and 354. The exclusion of petroleum and coal products from manufacturing is justified on the grounds that petroleum refining and coal processing are part of the energy sector. A borderline case might be the manufacture of asphalt and roofing tar (SIC 295 and 299). Some sources, such as WAES, show raw materials or "feedstock" for asphalt and tar in connection with the energy demand of manufacturing industries. For the sake of comparability with other estimates we have excluded SIC 295 and 299 from the energy demand of the manufacturing sector.

Based on historical data and projections compiled by Brookhaven National Laboratory (BNL) the share of the manufacturing sector in total gross fuel use may be estimated as follows:

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[1]Data on armament industries (SIC 19) are included with miscellaneous (SIC 39) if and when available.

USA Gross Fuel Consumption

Sectors	Unit	1947	1967	1985	2000
Agriculture, Mining, and Construction	10^{15}BTU	1.41	2.70	4.00	6.80
Manufacturing Excluding Petroleum and Coal Products	"	8.30	15.00	28.34	53.05
Other Sectors	"	20.82	38.22	66.01	81.05
All Sectors	"	30.53	55.92	98.35	140.90
Manufacturing as Percent of All Sectors	%	27	27	29	38

After BNL [14; p.4, table 1].

The data show that a relatively small amount of energy is used by the sector comprising agriculture, mining, and construction; this is of some importance in the later analysis. One further sees that the manufacturing sector, adjusted as indicated above, represents less than 30% of gross fuel consumption in the pre-projection periods, and that it is assumed to increase to nearly 40% by the year 2000. These matters will be discussed in greater detail and in comparison with estimates from other sources (i.e. WAES) in the following notes.

Within the manufacturing sector, five energy-intensive industry groups (primary metals; chemicals; paper; stone, clay and glass; and food) absorb about 80% of the energy demand of all manufacturing industries and only 30% of the value added. The following notes and Tables 6 to 10 concentrate on the five energy-intensive industries (individually), other industries (en bloc), and total manufacturing. Energy consumption value added, and deflators for all manufacturing industries at two-digit industry levels, are shown in Tables 15 to 20.

Sources and Methods

Data on US energy demand and output by manufacturing industries are available from several sources. Table 1 gives an overview of the availability and type of data sought, definitions,

presentations, and years covered in the sources readily available at IIASA.

These are the US *Census and Annual Surveys of Manufactures*, also reproduced in the *Statistical Abstract* [1 to 5]; *Project Independence* of 1974 [6]; the Ford Foundation's *Energy Consumption in Manufacturing Industries* of 1974 [7]; the WAES *Energy Demand Studies* of 1976 and *Energy Supply-Demand Integrations* of 1977 [9 to 11]; the various Brookhaven estimates as contained in the *Input/Output Computer Printouts* for 1967 [12]; the *Sourcebook for Energy Assessment* of December 1975 [13]; the *Analysis of Past and Expected Future Trends in US Energy Consumption, 1947-2000* of February 1977 [14]; and finally the early work of W.A. Reardon at Battelle on the *Energy Use Changes from 1947 to 1958 and 1958 to 1963* [15].

Most estimates on energy consumption and output by manufacturing industries derive from the US *Census of Manufactures* by the Department of Commerce. The census is taken every five years (i.e. 1958; 1962; 1967; 1972; 1977) and provides detailed information on output and consumption of raw materials, fuels, and electricity. Together with other sources it is used for the input/output tables established by the Bureau of Economic Analysis (also of the Commerce Department), i.e. for 1958 and 1967; the latest after 1967 is not yet available at IIASA. A less detailed enumeration is made annually by means of a sample survey. Recently, the question on "purchased fuels and electricity for heat and power" was added to the *Annual Survey of Manufactures* [2 to 4].

Output by Manufacturing Industries

The data used by the various sources on the value of output represent either "value added" or "gross ouput"; the latter is similar to "shipments" and "sales". The census publications show the same amount of energy purchased for either "value of shipments" or "value added". See, for example, the "Manufactures

Summary for Industry Groups", a standard table in the US *Statistical Abstract* [5]. Since it is always the same amount of energy, it can be pro-rated against either "gross output" or "value added" of a given industry.

It may further be noted that the value of output data published by the census are always in terms of current dollars only. Consequently, all data found in the literature on output in constant prices are estimates. This has to be kept in mind when comparing historical data on the demand of energy per value of output. It was found that the deflator implicit in the value added at 1967 prices used by the Ford Foundation [7] was quite similar to the one used by *Project Independence* [6] for the years at which they overlapped. Therefore, we used the deflator implicit in the Ford Foundation study to convert the raw data from the census into constant prices of 1967 for the period 1947-1967. However, these deflators relate only to total manufacturing and six energy-intensive groups. We estimated the deflators for the other 14 groups on the basis of the difference between total manufacturing and the six groups mentioned above, plus adjustments where necessary, with the wholesale price index.

For more recent years, not covered in the Ford and Project Independence reports, we estimated value added at 1967 prices by extrapolation of the 1967 census value added by the Federal Reserve's Industrial Production Indexes for individual industries. To test the accuracy of these estimates we compared the growth rate with the index numbers 1967 = 100 implicit in the "Manufacturing Sales in Constant Dollars, 1959 to 1975" published in the *Survey of Current Business* of May 1976 [17; pp. 16]. Unfortunately, we had to resort to these somewhat complicated methods, because the value added by manufacturing industries at two-digit SIC level, published in *The National Income and Product Accounts of the US, 1929-1974* in the *Survey of Current Business Supplement* [16; table 63, p. 189], were only given in terms of current values. Moreover, a deflator of the census value added at current prices by the wholesale price index was not feasible for

several manufacturing groups. In order to obtain comparability with Ford, *Project Independence*, and Brookhaven projections, we then converted WAES 1972 values to the price level of 1967. Obviously, the data could be converted to a more recent price basis.

Fortunately, the above described compilation of value added in constant prices, and hence energy input per value added, were later found to agree largely with the (Conference Board) data quoted in the New York Times of 26 March 1978 [24].

Energy Demand Definitions

The estimates of energy demand by manufacturing industries are largely based on the censuses mentioned above. They provide data up to four digit industry level on "fuels and electricity purchased for heat and power" in values (current dollars) and quantities (kWh). To facilitate comparisons, we converted the kWh to BTU on the basis of 1 kWh = 3460 BTU. This showed more clearly the differences between the various estimates and the census on which they are based (see Table 2).

The data on electricity demand when shown separately from that of fuels, as in *Project Independence* [6] and WAES [9] agree closely with the Census; they represent, as stated above, "purchased electricity". Likewise the UN tables on US manufacturing industries' electricity demand for individual industries, shown in the *Growth of World Industry* [18], are raw census data on "purchased electricity to generate heat and power".

The difference between the census and the various estimates is in fuels, for reasons of coverage and concepts. As far as coverage is concerned, one has to recall that the census deals only with "purchases to generate heat and power", and therefore two major energy demand items are excluded:

- Fuels not purchased from the outside, i.e. captive coal consumption. This occurs mostly in the case of metallurgical coke used for primary metals production (SIC 33); this coal comes from mines owned by the steel companies.

● Fuels not used to generate heat and power but as raw materials or "feedstock" such as petroleum for the production of petrochemicals that are part of SIC 28 chemicals. Other feedstock, used for asphalt and roofing tar (part of SIC 29) is excluded from the present analysis, as stated above.

Both captive coal and petroleum feedstocks are large items. Based on the Ford estimates, the 1967 gross energy consumed for primary metals consisted to one third of captive coal [7; p. 21, table 1.3]. The share of petroleum feedstocks for petrochemicals is nearly 50% of the chemical industries' combined fuel and electricity demand in the WAES data for 1972 [9; page 522]. Therefore, the various attempts to fill the gaps left by the census explain some of the major differences between the various estimates with which we are presently confronted.

Other differences among the various estimates result from differences in the concept of energy demand (see also Table 1). The Brookhaven *Input/Output* compilations [12] relate to "useful energy". This is the amount of energy in terms of heat, light, mechanical power, etc., actually used to provide a given energy service, e.g. heat for warming a room, light for reading a book power for turning a lathe, etc. This useful energy is net of all losses that occur at various stages, such as conversion of primary to secondary energy; transportation of secondary energy; and finally losses caused by conversion or adaptation to provide the final service[2].

The Brookhaven *Analysis of Past and Expected Future Trends* [14] deals with primary fuels, involving a reconversion of secondary to primary. The Ford study on *Energy Consumption in Manufacturing Industries* [7; p. 7] considers gross energy consumed.

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[2]For definition of concepts see also IIASA Workshop on Energy Strategies, Conception and Embedding, Appendix p. 19, Laxenburg, May 1977 [19] and W. Häfele *On Energy Demand*, invited paper, XXI. General Conference of the International Atomic Energy Agency, Vienna, September 1977 [20].

This measure includes purchased electricity in terms of an average amount of fossil fuel required to make one kilowatt hour of electricity. On the other hand, the *Census* [1], *Project Independence* [6] and WAES [9] are concerned with the energy delivered to the manufacturing industries as the last consumers or "final demand". This is a mixture of primary (i.e. coal) and secondary energy (i.e. fuel oils; electricity). The difference between primary and secondary is not so significant for fuel oils, but for electricity multiplication by a factor of roughly 3.3 might be required to express electricity consumption in terms of primary fuels. In the *1972 Census*, fuels and electricity quantities are shown separately, except for standard tables 6 and 7 which present an unadjusted total "representing the kilowatt-hours equivalent of all fuels used for heat and power plus the quantity of purchased electricity" [1; SR-85, footnote 1]. *Project Independence* [6] and WAES [9] use unadjusted totals of delivered fuels and electricity for compilations of energy/output coefficients. The crude device of unadjusted totals for final fuels and electricity could be justified on the grounds that it suffices to study the long-term trends, if two conditions were met:

- The share of electricity in the manufacturing industries' energy demand is not very high; and
- It is not expected to change much in the course of the projections.

The first condition applies to the manufacturing sector as a whole for the base year 1972, when on the average, electricity amounted to 10.5% of the (unadjusted) energy demand. There are however important deviations from this average, i.e. transportation equipment and "other manufacturing" where the so-compiled electricity share is over 20%, and in the non-ferrous metals industry where it is over 30%. For details, see Table 3, "USA Consumption of Final Fuels and Electricity by Manufacturing Industries, 1972". As regards the second condition, it seems that both WAES and BNL foresee a higher share of electric power in future energy demands of the manufacturing sector. As stated in the WAES report "Minimum preferences for electricity in the

industrial sector in 2000 are...20 percent higher than the actual 1972 percentage" [10; p. 621 and table 19.3, p. 622]. For Brookhaven projections in this matter, see for instance their tables on "Percent of Total Energy Service Activity Occurring Within Selected Interindustry Sectors" [14; p. 24, table 10].

These factors should be kept in mind when comparing energy demand projections of WAES with those of BNL.

OBSERVATIONS

The time series on energy consumed, value added, and the energy required in terms of BTU to produce one dollar value added at 1967 prices for total manufacturing and five energy-intensive industries are shown in Tables 6 to 10. In Figures 1 to 6 the energy coefficients are plotted for the entire manufacturing sector excluding petroleum refining and coal products; and for the five energy-intensive industries total and individually. For an interpretation of the data, one should keep in mind the different methods used by the various sources, indicated above. These differences are reflected, at least for the pre-projection periods, in the levels of the coefficients.

USA 1967 Energy Coefficients, Manufacturing Sector[a]

	10^3 BTU per 1$ Value Added (at 1967 Prices)
US *Census* (final energy excl. captive coal and feedstocks)	41
Project Independence (final energy incl. captive coal and feedstocks)	48
Brookhaven *Analysis* (primary fuels incl. captive coal and feedstocks)	59
Ford Study *Manufacturing* (gross fuels, incl. captive coal and feedstocks)	61

a = Excluding Petroleum and Coal Products
Source: See Tables 6 to 10.

Historical Growth Rates

The message of the pre-projection period is that, regardless of the levels, all indicators point towards a decrease of the energy consumed per value added produced. The same trend is shown by all sources (US *Manufacturing Census*; Ford Report, *Project Independence*) to have occurred for total manufacturing and each of the five energy-intensive industries, since 1947 or some time thereafter until the present time. "The present time" for the Ford Study, *Project Independence*, and WAES means early 1970s, as at the time of their compilation the results of the Annual Surveys for 1974 and later years were not yet at hand. They have since become available, showing continued increase in the efficiency of energy use in the manufacturing sector as a whole and in individual industries, though at differing intensities and expectations. Moreover, another means of assessing progress in recent energy conservation has become available through the monitoring of progress achieved in the implementation of the Federal law of 1974 favoring voluntary energy conservation.

The average efficiency of energy utilization in the manufacturing sector (excluding coal and petroleum products) as measured by the *Census* data has increased from 75,000 BTU to produce one dollar value added (at 1967 prices) in 1947 to 41,000 BTU in 1971, and since then to 33,000 BTU in 1976 (see Table 6). In 1971, the manufacturing companies purchased 11.5×10^{15} BTU of energy from the outside, compared with 11.3×10^{15} BTU in 1976, according to the *Census* data. If one adds to these purchases the energy that is self-produced by the manufacturing companies, the so-called self-generated electricity, and the coke made from coal mines owned by steel companies, the efficiency of energy utilization still continued to increase. This was commented upon by the New York Times in an article on *The Energy Efficiency of US Industry* by Victor K. McElheny [24].

What are the factors that caused this improvement, though small in some industries, that occurred during the recent re-

cession? Does this performance reflect the impact of price elasticities? Is it the outcome of the above mentioned 1974 Federal law to spur energy conservation in industry by means of a voluntary program? Were new, energy-saving, plants and equipment installed to replace older plants that had been built when energy was cheap? Has the product mix changed in favour of less energy-intensive industries? An answer to these questions might help to get a firmer basis for the projections. A step in this direction might be to look at the long-term growth observed for individual energy-intensive industries.

For the chemicals industries, the historical data show considerable and continued improvements (see also Figure 4). Improved energy efficiencies continued in the very recent period, according to a progress report on the implementation of the Energy Conservation Program. Using 1972 as a base year, the program sets goals for energy efficiency that are to be achieved by 1 January 1980. Between 1972 and 1976, the chemicals are reported to have achieved a nine percent improvement (14 percent was sought).

In the paper industries, energy efficiency has greatly improved over the years (see Figure 5). Further and bigger savings of energy input are expected from technological changes, through the burning of waste as a source of energy. This process has been known for some time. However, the progress in energy savings, as measured under the above mentioned program, is reported to be 50% below target [24].

The group of "stone, clay, and glass" which includes cement, has also shown continuous improvement in energy efficiency (see Figure 6). However, like in the case of paper, mentioned above, the savings were disappointingly small in the recent years [24].

On the other hand, fuel conservation has come up to expectations in the "petroleum refining and coal mining industries" and the "nonelectrical machinery manufacturing" that had met their goals of 12, respectively 15, percent savings [24].

An industry whose energy input merits particular attention is the group of "primary metals". The historical downward course of energy quantity input per value of output has at times been interrupted by short upward stretches (see Figure [3]). This is so because the primary metals are particularly sensitive to cyclical effects[3]. As stated in the Ford report on *Manufacturing Industries* [7; p. 11] the energy input per short ton of raw steel was trendwise comparatively low in 1969 when production and capacity utilization were high; in 1958 and 1971, when production and capacity utilization were low, the energy input per output was comparatively high. As stated in the Ford Study, "one reason for this is simply the avoidance, at high levels of output, of reheating furnaces or boilers that are allowed to cool during the slack periods" [7; p. 11]. The relatively poor performance of slack periods may explain to some extent why the energy savings envisaged under the above mentioned voluntary program had by 1976 reached less than 50% of the target set for primary metals. Another reason may be the fact that during and after the recent recession, companies may prefer to accumulate cash rather than spending money for such expansionist items as research and development, and installation of new, energy saving, plants and equipment. In fact, the slowdown in capital spending is thought by some to be responsible for the fact that the "large-scale" basic energy-intensive industries, such as metals and paper, have been conserving energy more slowly than other industries[4] [24].

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[3]The primary metals industry shows the only instance where the different sources do not seem to agree. From 1958 to 1962, *Census* data (purchased fuels and electricity for heat and power) point to an increase, and Ford and *Project Independence* (purchased fuels and electricity plus captive coal) show a decrease of energy used per value added. A disaggregation of the data shows that the energy efficiency derived from captive coal became so strong that it overshadowed the increase in energy per value added of the purchased fuels and electricity.

[4]Quotations in the New York Times [24] of Mr. Gelb, economist of the Conference Board. It may be noted that the Conference Board, Energy Information Centre, prepared the study on *Energy Consumption in Manufacturing Industries*, which was published in 1974 as part of the Ford Foundation energy policy project [7]. It is understood that this study is now being updated [24].

Projections to the Year 2000 (Comparison of Estimates)

All projections show continued growth of manufacturing output. The question is, will the tendency for less energy per output observed in the past continue in the years to come? The various projections point towards a continuation of this trend for the "near future", up to 1985 (Ford Report; *Project Independence*; Brookhaven; and WAES for low and high economic growth). For the period 1985 to 2000, the trend implicit in the WAES projections sees further reductions in the use of energy per output, whereas the Brookhaven projections show that the end of the long line of rising energy efficiency in manufacturing industries is reached by 1985; thereafter, until the year 2000, the efficiency seems to decrease.

Here are some direct quotations from the two reports. As stated by WAES:

...In the industrial sector, energy use per dollar of output is projected to decrease between 1985 and 2000 at a rate of 0.8 percent per year for primary metals and 1.5 percent per year for other energy-intensive industries [10; p. 626].

The Brookhaven table on "Energy per Unit of Output" indicates that energy per unit of output will decrease 0.4% per year during the period 1967-1985 and increase 0.9% per year during 1985-2000 [14; p. 11]. As stated in the text: "... In the 1985-2000 period relative to the 1967-1985 period energy consumption per unit of output is expected to accelerate ... [14, p. 11/17].

In order to find an explanation for the apparent contradiction in the messages on future energy efficiency in manufacturing coming from the two reports, it may be useful to have a look at some of the assumptions underlying the projections:

- economic activity on energy demand growth rates;
- share of manufacturing in total energy demand;
- product mix, technological innovations.

This analysis omits other factors which could also have an impact, such as elasticity of energy prices; government policy and

effectiveness of energy conservation measures; availability of capital and willingness to invest in energy saving devices.

Economic Activity and Energy Demand Growth Rates

Compiled from various sections of the WAES and BNL reports, the annual growth rates for economic activities (GNP and manufacturing output) and energy demand (final and primary energy all sectors and manufacturing sector) are shown in Table 4. For details, see also Tables 11 to 14 on growth assumptions in various scenarios and projections. The tables show that there is considerable agreement between WAES and BNL on the growth rates of economic activity as expressed by total GNP and total manufacturing ouput. A discrepancy exists as to the growth of energy demand, especially by the manufacturing sector. This apparent discrepancy is largely due to the fact that the BNL energy demand projections are in terms of primary energy; this means that account is taken of additional amounts of primary fuels required to meet the rapidly growing demand for electrification. Whereas the WAES data which are in terms of final energy exclude such calculations, they represent straight extrapolations of the historical growth rates for final energy.

Share of Manufacturing in Total Energy Demand

As shown in Table 5 on "The Share of Industry in Total Energy Demand" both BNL and WAES expect that the energy consumption by the manufacturing sector as percent of total energy demand will increase. According to BNL the increase in terms of primary fuels will be from 27% in 1967 to 29% in 1985 and 38% in 2000. According to WAES the increase in terms of final energy will be from 32% in 1972 to 40% in 1985 and 47% in 2000 under "high" growth of activities, and to 36% in 1985 and 41% in 2000 under "low" growth.

The commentary offered by the two reports on the rising share of manufacturing and industry in total energy demand is stated by the BNL:

"The estimated 1985 to 2000 trend toward greater concontration of energy consumption within industry partially reflects greater than average expected improvements in the efficiency of nonmanufacturing uses of energy. In particular, ERDA estimates that in this time period transportation end use efficiencies will significantly increase and that space heating requirements will decline via improved insulation. Much smaller efficiency improvements are expected in manufacturing-oriented activities, such as process heat, feedstock, and direct electric drive activities. It should also be mentioned that this trend toward greater concentration of energy consumption within industry over time has also been forecasted by econometricians. They estimate that a greater degree of non-energy for energy substitution exists outside of the manufacturing sector". [14; p. 13/14]

The WAES notes that "The data...indicate a continuing shift away from energy usage by individual consumers and toward energy use by industry..." [10; p. 627]. The message implicit in these statements is that greater savings in energy conservation may be forthcoming from the transportation, commercial, public, and residential sectors [10; p. 627].

Product Mix, Technological Innovations, Materials Switching

During the past period of abundant and relatively inexpensive energy supply, the factors that accounted largely for energy savings per value of output were shifts in the product mix and technological innovations.

Product mix. With the plight of the steel industries continuing for some time in the future, there is a possibility for a decrease in the amounts of energy required for the primary metals industries (though not a decrease in the amount of fuel per unit of output). On the other hand a development in the opposite direction, towards other, energy-intensive, industries, has also to be reckoned with. Both the Brookhaven and WAES reports foresee a shift in the product mix favoring the energy-intensive, petrochemicals industries (to pay for higher oil imports according to the BNL analysis). Moreover, the Brookhaven analysis foresees a higher percentage in heavy machinery and

capital goods production for public utility construction as an element to increase the manufacturing sector's energy demand [14; p. 12]; and as stated above, rising preference for electricity.

An increased output of chemicals and increased demand for feedstocks is also foreseen in the WAES projections.

Technological innovations. Examples for important increases in processing efficiencies are savings of energy by capture of process heat in primary metals industries and the conversion of wastes to energy in the paper industries. As shown under the recent capital crunch 1974-1976, the energy savings in these industries did not come up to expectations. However, the BNL foresees continuation of the energy saving trend in the paper industry beyond 1985. Based on BNL projections for energy demand and value added, paper is the only industry where the energy per value added coefficient continues to decrease for 1985 to 2000 (see data, Table 9).

Materials switching. Savings in the energy consumption can also be expected from materials switching; in the automobile sector they could materialize if the FEA mandated fuel efficiency requirements succeed with automobiles becoming lighter over time, using more aluminium and plastics and less steel and glass [14; p. 27]. The "miniaturization" or process by which over time fewer and fewer pounds of materials were incorporated in each product (as seen in the decreasing weights of radios, computers), has greatly contributed in the past to reduce the energy per value added coefficient. The question is: To what extent will this and other energy saving devices continue to prevail in the future?

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Table 1. Overview of Availability of Data on Energy Demand and Output by Manufacturing Industries.

	US Census of Manufacturing [1]	Project Independence [6]	Ford; Manufacturing Report [7]	WAES [10]	Brookhaven Input/Output [12]	Brookhaven Analysis (Feb.77) [14]	Brookhaven Sourcebook (1975) [13]	Reardon,W.M. Battelle 1972 [21]
Energy Demand								
Coverage								
Purchased Heat and Power	x	x	x	x	x	x	x	x
Captive Coal (Primary Metals)	-	x	x	x	x	x	x	x
Feedstock (Petrol Refining, Some Chemicals)	-	x	-	x	x	x	x	x
Concept								
Primary Fuel "Purchases"	-	-	-	-	-	x	-	-
Gross Consumption	-	-	-	-	-	-	-	-
Final Consumption	x	x	-	x	-	-	-	-
Useful Consumption	-	-	-	-	x	-	-	-
Direct + Indirect Cons.	-	-	-	-	-	-	-	x
Total Direct Use	-	-	-	-	-	-	x	-
Output								
Gross Output (Shipments)	x	-	x	-	x	x	-	x
Value Added	x	x	x	x	-	-	-	-
Years Covered Observed	Energy 1947;1954;1958; 1962;1967;1971; 1974;1975;1976 Output:Annual	En.+Output 1954;1958 1962;1967; 1971	En.+Output 1947;1954; 1958;1962; 1967;1971	En.+Output 1972	En.+Output 1967	En.+Output 1967	En.+Output 1972	En.+Output 1957;1958; 1963
Projections	-	(1975);1977; 1980;1985; 1990	(1975) 1980	1985 2000	1985 2000	1985;1990 2000		- -

Sources: See reference numbers.

Table 2. USA Energy Consumption by the Manufacturing Sector, Excluding Petroleum and Coal Products, Various Estimates for 1967 and 1971.

	Fuels 10^{12}BTU	Electricity 10^{12}BTU	Total 10^{12}BTU
1967			
Brookhaven, Analysis [14] Primary Fuel	.	.	15002
Ford Foundation [7] Gross Energy	.	.	15557
Project Independence [6] Final Energy	10810	1396	.
US Census [1] Final Energy	9015	1396	.
Brookhaven, Input/Output [12] Useful Energy	.	.	9655
1971			
Ford Foundation [7] Gross Energy	.	.	16821
Project Independence [6] Final Energy	11452	1677	.
US Census [1] Final Energy	9804	1685	.
WAES [9] Final Energy	14376[a]	1813[a]	17189[a]

a = 1972

Sources: See reference numbers.

Table 3. USA Consumption of Final Fuels and Electricity by Manufacturing Industries, 1972; After WAES.

Industries	Fossil Fuels 10^{12}BTU	Electricity 10^{12}BTU	Total 10^{12}BTU	Share of Electricity %
Iron and Steel	3382	206	3588	5.7
Nonferrous Metals	580	276	856	32.2
Paper and Allied	1419	128	1547	8.3
Chemical	5583[b]	370	5953	6.2
Mineral Products	1376	96	1472	6.5
Food and Related	892	119	1011	11.8
Transportation Equipment	323	102	425	24.0
Other Manufacturing	1821	516	2337	22.1
Total Manufacturing[a]	15376[b]	1813	17189[a;b]	10.5

b = Includes feedstocks, 2929 x 10^{12}BTU

a = Excludes asphalt and road tar feedstocks, and petroleum and coal products

Source: After WAES *Energy Demand Studies* [9; p. 522/523].

Table 4. USA Economic Activities and Energy Demand, Projected Annual Growth Rates, 1985 to 2000; a Comparison of BNL and WAES Estimates.

	BNL	WAES	
		"C"High	"D"Low
Economic Activities			
●GNP	3.1%	3.5%	2.5%
●Manufacturing Output	3.2%	3.7%	2.9%
Energy Demand			
●All Sectors			
Final Energy	.	1.7%	1.2%
Primary Energy	2.4%	.	.
●Manufacturing Sector			
Final Energy		2.7%	1.9%
Primary Energy	4.2%	.	.

Sources: Compiled from D.J. Behling, *BNL Analysis* [14] and WAES *Supply-Demand Integrations* [10].

Table 5. USA The Share of Industry in Total Energy Demand, 1947 to 2000; Selected Years; A Comparison of BNL and WAES Estimates.

Sectors	1947	1967	1972	1985			2000		
	BNL Gross Fuel Use	BNL Gross Fuel Use	WAES Final Energy	BNL Gross Fuel Use	WAES Final Energy "C"High	WAES Final Energy "D"Low	BNL Gross Fuel Use	WAES Final Energy "C"High	WAES Final Energy "D"Low
	In Quads (10^{15}BTU)								
Agriculture, Mining, Construction	1.4	2.7	2.0	4.0	2.7	2.1	6.8	4.2	2.8
Manufacturing[a]	8.3	15.0	17.2	28.3	27.3	24.7	53.0	41.0	33.0
Other Sectors (Transport, Residential, etc.)	20.8	38.2	33.8	66.0	37.8[b]	41.3[b]	81.1	42.0	45.5
T o t a l	30.5	55.9	53.0	98.3	67.8[b]	68.1[b]	140.9	87.2	81.3
	In Percent								
Agriculture, Mining, Construction	5	5	4	4	4	3	4	5	3
Manufacturing[a]	27	27	32	29	40	36	38	47	41
Other Sectors (Transport, Residential, etc.)	68	68	64	67	56	61	58	48	56
T o t a l	100	100	100	100	100	100	100	100	100

a = Adjusted to exclude petroleum and coal products

b = There seems to be a minor misprint in WAES

Sources: Compiled from D.J. Behling, *BNL Analysis* [14; table 1, p.4] and WAES *Supply-Demand Integrations* [10; table 19.7, p.626]

Table 6. USA Manufacturing Industries Excluding Petroleum and Coal Products; Final Energy Purchases for Heat and Power, and Value Added at 1967 Prices; After US Census of Manufactures.

		Unit	Food	Paper	Chemicals	Stone, Clay	Primary Metals	Total Energy-Intensive	Other Manufacturing	Total Excl. Petroleum & Coal Prod.
1947	Energy Consumption	10^{12}BTU	857	635	1023	929	2547	5991	2197	8188
	Value Added	10^{9}\$	15.56	3.92	5.16	4.14	12.40	41.18	67.70	108.88
	Energy per 1$ V.A.	10^{3}BTU	55	162	198	224	205	205	23	75
1954	Energy Consumption	10^{12}BTU	805	648	1275	904	1818	5450	1459	6909
	Value Added	10^{9}\$	16.96	5.14	8.47	5.13	12.77	48.47	88.80	137.27
	Energy per 1$ V.A.	10^{3}BTU	47	126	151	176	142	112	16	50
1958	Energy Consumption	10^{12}BTU	764	805	1541	945	1766	5821	1490	7311
	Value Added	10^{9}\$	19.66	6.03	11.30	5.89	12.44	55.32	90.90	146.22
	Energy per 1$ V.A.	10^{3}BTU	39	133	136	160	142	105	16	50
1962	Energy Consumption	10^{12}BTU	801	928	1876	1054	2302	6961	1701	8662
	Value Added	10^{9}\$	22.44	7.46	15.78	6.94	15.22	67.84	115.80	183.64
	Energy per 1$ V.A.	10^{3}BTU	37	124	119	152	151	103	15	47
1967	Energy Consumption	10^{12}BTU	900	1156	2459	1228	2421	8164	2247	10411
	Value Added	10^{9}\$	26.62	9.76	23.55	8.33	19.98	88.24	168.30	256.50
	Energy per 1$ V.A.	10^{3}BTU	34	118	104	147	121	93	13	41
1971	Energy Consumption	10^{12}BTU	1030	1313	2776	1303	2448	8870	2667	11537
	Value Added	10^{9}\$	30.10	11.80	29.70	9.2	20.00	100.80	179.5	208.3
	Energy per 1$ V.A.	10^{3}BTU	34	111	93	142	122	88	15	41
1972	Value Added[a]	10^{9}\$	31.1	12.6	34.0	10.0	22.4	110.1	199.2	309.3
1973	Value Added[a]	10^{9}\$	32.2	13.4	36.6	11.1	25.4	118.7	220.5	339.2
1974	Energy Consumption	10^{12}BTU	955	1330	3035	1335	2039	9294	2626	11920
	Value Added	10^{9}\$	33.0	13.2	37.5	11.0	24.6	119.3	218.8	338.1
	Energy per 1$ V.A.	10^{3}BTU	29	101	81	121	107	78	12	35
1975	Energy Consumption	10^{12}BTU	917	1209	2778	1159	2233	8296	2379	10675
	Value Added	10^{9}\$	32.7	11.4	34.7	9.8	19.2	107.8	195.2	303.0
	Energy per 1$ V.A.	10^{3}BTU	28	106	80	118	116	77	12	35
1976	Energy Consumption	10^{12}BTU	946	1299	2991	1216	2376	8828	2488	11316
	Value Added	10^{9}\$	35.1	13.0	39.9	11.4	21.8	121.2	218.1	339.3
	Energy per 1$ V.A.	10^{3}BTU	27	100	75	107	109	73	11	33

a = For 1972 and 1973, the *Annual Survey of Manufacturers* [2] did not collect the *quantities* of fuels purchased; only the *cost* of fuels purchased is available. However, for electricity quantity and cost data are published.

Table 7. USA Manufacturing Industries Excluding Petroleum and Coal Products; Gross Energy Consumption and Value Added at 1967 Prices; Selected Years 1946-1980; After Ford Study.

		Unit	Food	Paper	Chemicals	Stone, Clay	Primary Metals	Total Energy-Intensive	Other Manufacturing	Total Excl. Petroleum & Coal Prod.
1947	Energy Consumption	10^{12}BTU	857	635	1023	929	3620	7064	2197	9261
	Value Added	10^{9}\$	15.56	3.92	5.16	4.14	12.40	41.18	65.61	106.79
	Energy per 1$ V.A.	10^{3}BTU	55	162	198	224	292	172	33	87
1954	Energy Consumption	10^{12}BTU	883	801	1753	1032	3552	8021	2103	10124
	Value Added	10^{9}\$	16.96	5.14	8.47	5.13	12.77	48.47	88.14	136.61
	Energy per 1$ V.A.	10^{3}BTU	52	156	207	201	278	165	24	74
1958	Energy Consumption	10^{12}BTU	951	932	2282	1058	3462	8685	2273	10958
	Value Added	10^{9}\$	19.66	6.03	11.30	5.89	12.44	55.32	94.26	149.58
	Energy per 1$ V.A.	10^{3}BTU	48	155	202	180	278	157	24	73
1962	Energy Consumption	10^{12}BTU	992	1068	2592	1178	4130	9960	2570	12530
	Value Added	10^{9}\$	22.44	7.46	15.78	6.94	15.22	67.84	119.75	187.59
	Energy per 1$ V.A.	10^{3}BTU	44	143	164	170	271	147	21	67
1967	Energy Consumption	10^{12}BTU	1098	1367	3257	1341	4997	12060	3517	15577
	Value Added	10^{9}\$	26.62	9.76	23.55	8.33	19.98	88.24	168.32	256.56
	Energy per 1$ V.A.	10^{3}BTU	41	140	138	161	250	137	21	61
1971	Energy Consumption	10^{12}BTU	1286	1560	3473	1444	4945	12708	4113	16821
	Value Added	10^{9}\$	28.71	10.80	29.08	8.78	18.95	96.32	199.05	295.37
	Energy per 1$ V.A.	10^{3}BTU	45	144	119	164	261	132	21	57
1975	Energy Consumption	10^{12}BTU	1284	1725	4997	1617	6011	15634	5182	20816
	Value Added	10^{9}\$	33.44	13.89	42.98	10.61	26.73	127.65	266.28	393.93
	Energy per 1$ V.A.	10^{3}BTU	38	124	116	152	225	122	19	53
1980	Energy Consumption	10^{12}BTU	1453	1771	6020	1864	6748	17856	6318	24174
	Value Added	10^{9}\$	38.83	16.98	59.23	12.96	31.87	159.42	350.23	509.65
	Energy per 1$ V.A.	10^{3}BTU	37	104	102	144	212	112	18	47

Source: Compiled from *Energy Consumption in Manufacturing Industries* [7, pp. 18-21].

Table 8. USA Manufacturing Industries Excluding Petroleum and Coal Products; Final Energy Consumption and Value Added at 1967 Prices; Selected Years 1954-1990; After Project Independence.

		Unit	Food	Paper	Chemicals	Stone, Clay	Primary Metals	Total Energy-Intensive	Other Manufacturing	Total Excl. Petroleum & Coal Prod.
1954	Energy Consumption	10^{12}BTU	805	648	1359	905	2873	6590	1475	8065
	Value Added	$10^{9}$$	16.96	5.14	8.47	5.13	12.77	48.47	88.14	136.61
	Energy per 1$ V.A.	10^{3}BTU	47	126	160	176	225	135	17	59
1958	Energy Consumption	10^{12}BTU	766	806	1634	945	3049	7200	1478	8678
	Value Added	$10^{9}$$	19.66	6.03	11.30	5.89	12.44	55.32	94.26	149.58
	Energy per 1$ V.A.	10^{3}BTU	39	134	145	160	245	130	16	58
1962	Energy Consumption	10^{12}BTU	803	929	1969	1056	3599	8356	1827	10185
	Value Added	$10^{9}$$	22.44	7.46	15.78	6.94	15.22	67.84	119.75	187.59
	Energy per 1$ V.A.	10^{3}BTU	36	125	125	152	236	123	15	54
1967	Energy Consumption	10^{12}BTU	767	1156	2598	1229	4080	9830	2379	12209
	Value Added	$10^{9}$$	26.62	9.76	23.55	8.33	19.98	88.24	168.32	256.56
	Energy per 1$ V.A.	10^{3}BTU	29	118	110	148	204	111	14	48
1971	Energy Consumption	10^{12}BTU	920	1315	2783	1367	4030	10415	2714	13129
	Value Added	$10^{9}$$	28.77	11.36	29.08	9.32	18.95	97.48	199.05	296.53
	Energy per 1$ V.A.	10^{3}BTU	32	116	96	147	213	107	14	44
1975	Energy Consumption	10^{12}BTU	912	1378	3757	1407	4810	12264	3538	15802
	Value Added	$10^{9}$$	32.95	13.89	40.31	10.64	24.58	122.37	260.17	382.54
	Energy per 1$ V.A.	10^{3}BTU	28	99	93	132	196	100	14	41
1977	Energy Consumption	10^{12}BTU	939	1448	4428	1457	4964	13236	4046	17282
	Value Added	$10^{9}$$	34.80	14.89	47.78	11.72	26.42	135.61	297.50	433.11
	Energy per 1$ V.A.	10^{3}BTU	27	97	93	124	188	98	14	40
1980	Energy Consumption	10^{12}BTU	1001	1567	4822	1566	5162	14118	4657	18775
	Value Added	$10^{9}$$	38.08	16.61	57.39	13.10	29.01	154.19	342.40	496.59
	Energy per 1$ V.A.	10^{3}BTU	26	94	84	120	178	92	14	38
1985	Energy Consumption	10^{12}BTU	1154	1742	6175	1702	5519	16292	5602	21894
	Value Added	$10^{9}$$	43.86	19.70	76.68	15.32	33.26	188.82	411.90	600.72
	Energy per 1$ V.A.	10^{3}BTU	26	88	81	111	166	86	14	36
1990	Energy Consumption	10^{12}BTU	1345	1947	7481	1900	5924	18597	7442	26039
	Value Added	$10^{9}$$	50.81	23.99	102.82	17.94	38.35	233.91	547.22	781.13
	Energy per 1$ V.A.	10^{3}BTU	26	81	73	106	154	80	14	33

Source: Compiled from *Project Independence* [6, Table 2, p.1-7 to 1.9].

Table 9. USA Manufacturing Industries Excluding Petroleum and Coal Products; Primary Fuel "Purchases" and Value Added in 1967 Prices; Selected Years 1947-2000; After Brookhaven Analysis.

		Unit	Food	Paper	Chemicals	Stone, Clay	Primary Metals	Total Energy Intensive	Other Manufacturing	Total Excl. Petroleum & Coal Prod.
1947	Energy Consumption	10^{12}BTU	.	.	.	.	.	.	.	8300[a]
	Value Added	10^{9}\$								108.80
	Energy per 1\$ V.A.	10^{3}BTU	.	.	.	.	.	.	.	76[a]
1967	Energy Consumption	10^{12}BTU	1116	1401	4153	1679	3721	12070	2932	15002
	Value Added	10^{9}\$	26.6	9.8	23.6	8.3	20.0	88.3	168.1	256.4
	Energy per 1\$ V.A.	10^{3}BTU	42	143	176	202	186	137	17	59
1985	Energy Consumption	10^{12}BTU	1612	2333	9907	2282	6871	23005	5338	28343
	Value Added	10^{9}\$	41.5	18.2	62.4	15.1	60.8	198.0	291.7	489.7
	Energy per 1\$ V.A.	10^{3}BTU	39	128	159	151	113	116	18	58
2000	Energy Consumption	10^{12}BTU	2773	3936	20756	3842	12274	43581	9474	53055
	Value Added	10^{9}\$	66.5	68.1	107.9	24.1	95.5	362.1	424.5	786.6
	Energy per 1\$ V.A.	10^{3}BTU	42	58	192	159	129	120	22	67

a = Estimated

Source: Compiled from D.J.Behling [14].

Table 10. USA Manufacturing Industries Excluding Petroleum and Coal Products; Final Energy Consumption and Value Added in 1967 Prices; Selected Years 1972-2000; After WAES.

		Unit	Food	Paper	Chemicals	Stone, Clay	Primary Metals	Total Energy Intensive	Other Manufacturing	Total Excl. Petroleum & Coal Prod.
1972	Energy Consumption	10^{12}BTU	1011	1547	5953	1472	4444	14427	2762	17189
	Value Added	$10^{9}$$	30.59	11.07	31.77	11.07	19.03	103.52	195.00	298.52
	Energy per 1$ V.A.	10^{3}BTU	33	140	187	133	234	139	14	58
1985	Energy Consumption	10^{12}BTU	.	.	11140	.	7100	23240	4100	27340
(C_1+C_2)	Value Added	$10^{9}$$	.	.	98.30[a]	.	38.55	213.50	314.54	528.04
High	Energy per 1$ V.A.	10^{3}BTU	.	.	113	.	184	109	13	52
1985	Energy Consumption	10^{12}BTU	.	.	10170	.	6000	20870	3600	24 470
(D)	Value Added	$10^{9}$$	.	.	92.61[a]	.	30.87	195.86[a]	274.37	470.23[a]
Low	Energy per 1$ V.A.	10^{3}BTU	.	.	110	.	194	107	13	52
2000	Energy Consumption	10^{12}BTU	.	.	16710	.	11600	34810	6200	41010
(C_1+C_2)	Value Added	$10^{9}$$	.	.	194.16	.	61.26	381.97	554.22	913.19
High	Energy per 1$ V.A.	10^{3}BTU	.	.	86	.	189	91	11	45
2000	Energy Consumption	10^{12}BTU	.	.	14050	.	8500	28150	4900	33050
(D7;D8)	Value Added	$10^{9}$$	.	.	147.65	.	47.39	298.33	412.10	710.43
Low	Energy per 1$ V.A.	10^{3}BTU	.	.	95	.	179	94	12	47

Source: Compiled from WAES *Energy Demand Studies* 1972 demand and 1985 projections [9, p.522]; and WAES *Supply-Demand Integrations* [10, p.626; table 19.7].

a = Correction of misprint in original source

Table 11. USA Growth Assumptions in Various Scenarios and Projections of Population and Energy Prices; Real Annual Growth Rates (%).

		1967-1975	1975-1985	1985-1990	1985-2000	1990-2000	2000-2010	2000-2025	2000-2030
Population									
IIASA (Keyfitz)		0.926	0.737		0.677			0.401	0.401
Project Independence		.	0.977[a]						
WAES		.	0.88[b]		0.776				
Oak Ridge IEA Low		.	0.68		0.48		0.20		
Oak Ridge IEA High		.	0.81		0.63		0.39		
CONAES		.	0.82		0.83		0.59		
Energy Prices									
●*Oil*[c]									
BNL, Analysis	Dom. Crude	7.3	4.7	1.0		2.0			
BNL, Analysis	Imp. Crude	13.7	-.1	1.0		2.0			
WAES C High	{Arab. Light,	.	0.0[b]		0.0-2.7				
WAES D Low	{f.o.b.Pers.Gulf	.	0.0[b]		0.0				
Oak Ridge IEA	composite cost to refiners	.	4.4		3.0		3.0		
Ford, Time to Choose									
Crude }	Historical	.	4.76		4.44				
Refined }	Growth Path	.	5.74		4.54				
●*Natural Gas*									
BNL, Analysis		8.1	16.2	0.5		1.0			
WAES									
Oak Ridge IEA	Wellhead Prices								
Ford, Time to Choose	Hist.Growth Path		5.96		4.94				
●*Coal*									
BNL, Analysis		14.2	-2.9		0.5[d]-1.0[d]	0.5[d]-1.0[d]			
WAES		.	.		.	.			
Oak Ridge IEA	{Delivered to Utilities		2.0		2.0		1.9		
Ford, Time to Choose	Hist.Growth Path		1.78		5.72				

a = 1973-1985
b = 1972-1985
c = See also ERDA and CONAES in Oak Ridge, IEA, Executive Summary [21; p.62].
d = Strip mined: 0.5; underground = 1.0.

Table 12. USA Growth Assumptions in Various Scenarios and Projections of Population and Energy Prices; Absolute Amounts.

	Unit	1967	1975	1980	1985	2000	2010	2025	2030	2050
Population										
IIASA (Keyfitz)	10^6	198.7	213.9	230.2	230.2	254.7	.	281.5	.	286.9
Project Independence	10^6		210[a]		236					
WAES	10^6		208.8[b]		234.1	262.5				
Oak Ridge IEA Low	10^6		213		228	245	250			
Oak Ridge IEA High	10^6		213		231	254	264			
CONAES	10^6		213.5		231.7	262.3	278.2			
Energy Prices										
●*Oil*										
WAES C High	1bbl Arab.Light Crude; f.o.b. Pers.Gulf in $'75		11.5		11.5	11.5-17.25				
WAES D Low			11.5		11.5	11.5				
Oak Ridge IEA	1bbl Composite Cost to Refineries in $'75		10.40		16.02	24.96	33.59			
●*Natural Gas*										
Oak Ridge IEA	10^3 cubic feet at Wellhead in $'75		0.43		2.76	4.30	5.76			
Ford, Time to Choose	Hist. Growth Path		17.5		21.35	28.88	35.00			
●*Coal*										
BNL, Analysis										
Oak Ridge IEA	1ton Delivered to Utilities in $'75									

a = 1973
b = 1972

Table 13. USA Growth Assumptions in Various Scenarios and Projections of GNP Total and by Components.

	Unit	Absolute Amounts						Real Annual Growth Rates (%)					
		1967	1975	1985	1990	2000	2030	1967-1975	1975-1985	1985-2000	1990-2000	2000-2010	2000-2030
GNP Total at Constant Prices													
IIASA En.Stat.Rep.1978	10^9'72	.	1192	1802	2223	2929	.	.	4.0[c]	3.2	2.8	.	1.48
BNL, Analysis	10^9'72	1008	1192	1781	.	2815	.	2.3	4.1	3.1	.	.	.
Ford, Time to Choose	10^9'71	.	1442	2064	.	3345	.	.	3.6	3.3	.	.	
Ford, Manufacturing	constant	.	.	.	.	.	.	.	4.3[d]	.	.	.	.
Project Independence	10^9'58	.	840[b]	1280	.	.	.	.	3.5[e]	.	.	.	.
WAES C High		.	.	.	.	.	.	.	4.4	3.5	.	.	.
WAES D Low		.	.	.	.	.	.	.	3.2	2.5	.	.	.
Oak Ridge IEA Low		.	.	.	.	.	.	.	3.6	2.7	.	2.5	.
CONAES		.	.	.	.	.	.	.	2.7	2.0	.	.	.
GNP by Components													
●*Consumption (Private)*													
IIASA En.Sta.Rep.1978	10^9'72	.	775	1154	1389	1773	2582	.	4.0	2.9	2.5	.	1.3
BNL, Analysis	10^9'72	.	.	.	.	.	.	3.3	4.0	3.1	.	.	.
●*Investment (Priv. and Gov.)*													
IIASA En.Sta.Rep.1978	10^9'72	.	215	333	433	585	918	.	4.5	3.8	3.1	.	1.5
BNL Private Only	10^9'72	.	.	.	.	.		-0.8	6.7	3.0	.	.	.
●*Government Purchases*[a]													
BNL, Analysis	10^9'72	.	.	.	.	.	.	0.5	2.8	3.4	.	.	.
GNP Structure													
IIASA En.Stat.Rep.1978													
●*Private Consumption*	%	.	65	64	62.5	60.5	59	.	.	.	.	.	.
●*Investment (Priv. and Gov.)*	%	.	18	18.5	19.5	20.0	21	.	.	.	.	.	.
●*Government Purchases, Net Exports, etc.*	%	.	17	17.5	18.0	19.5	20	.	.	.	.	.	.

a = Government purchases of goods and services net of Government sales
b = 1973
c = 1976-1985
d = 1975-1980
e = 1976-1985

Table 14. USA Growth Assumptions in Various Scenarios and Projections of Energy Demand.

	Unit	Absolute Amounts							Annual Growth Rates (%)					
		1967	1975	1985	1990	2000	2010	2030	1967-1985	1975-1985	1985-2000	1985-2010	2000-2010	2000-2030
Energy Demand														
All Sectors														
IIASA En.Stat.Rep.1978	Final Energy	.	60.3	73.1	.	88.1	.	112[g]	.	.	.	.	.	.
BNL, Analysis	Gross Fuel	55.92	.	98.35	.	140.9	.	.	3.1[f]	.	2.4	.	.	.
WAES High (C_1+C_2)	Delivered		53.0[b]	67.8	.	87.2	.	.	.	1.9[c]	1.7	.	.	.
WAES Low D	Delivered		53.0[b]	68.1	.	81.3	.	.	.	1.9[c]	1.2	.	.	.
Ford, Time to Choose	Gross Fuel		78.0	115.0	.	184.7	.	.	.	4.0	3.2	.	.	.
Oak Ridge IEA Low	Direct Fuels		71.1	82.1	.	101.4	115.1	.	.	1.5	1.4	.	1.3	.
Oak Ridge IEA High	Direct Fuels		71.1	88.0	.	125.9	151.7	.	.	2.2	2.4	.	1.9	.
CONAES A			.	77.5	.	.	74.0	.	.	.		-0.19	.	.
CONAES B			.	85.5	.	.	94.0	.	.	.		0.4	.	.
CONAES C			.	94.0	.	.	124.0	.	.	.		0.1	.	.
Manufacturing Sector (Excl. Petroleum and Coal Processing)														
IIASA En.Stat.Rep.1978	Final Energy	.	25.7[a]	33.0[a]	.	42.8[a]	.	53[g]						
BNL, Analysis	Gross Fuel	15.0	.	28.3	.	53.0	.	.	3.6[f]	.	4.2	.		
WAES High (C_1+C_2)	Delivered	.	17.2[b]	27.3	.	41.0	.	.	.	3.6[c]	2.7	.		
WAES Low D	Delivered	.	17.2[b]	24.5	.	33.0	.	.	.	2.8[c]	2.0	.		
Ford, Manufacturing	Gross Fuel	13.9	20.8	24.2[d]	.	.	.	.	5.1	3.0[e]	.	.		
Ford, Time to Choose	Gross Fuel	.	26.9[a]	36.9[a]	.	49.5[a]	.	.	.	3.2	2.0	.		
Oak Ridge IEA Low	Direct Fuels	.	27.4[a]	35.5[a]	.	50.3[a]	61.3[a]	.	.	2.6	2.4	.		
Oak Ridge IEA High	Direct Fuels	.	27.4[a]	35.5[a]	.	58.1[a]	73.1[a]	.	.	2.6	3.3	.		
Project Independence	Final Energy	12.2	15.8	21.9	26.0	.	.	.	3.3	3.3	3.5	.		

a = Industry
b = 1972
c = 1972-1985
d = 1980
e = 1975-1980
f = 1967-1985
g = year 2025

Table 15. USA 1967 Useful Fuel and Electricity Used by Manufacturing Industries; Gross Output and BTU/$ Gross Output; After Brookhaven BNL 110.

US SIC Code	Manufacturing Industries	Gross Output (Value of Shipments)	Useful Fuel and Electricity Used (All Processes)	
			Total	BTU per Gross Output
		10^6 $	10^{12} BTU	BTU
20	Food, Beverages	83 975	615	7330
21	Tobacco	4 904	11	2260
22	Textiles	19 815	215	10856
23	Apparel	21 327	72	3376
24	Lumber	11 206	191	17044
25	Furniture	7 750	60	7742
26	Paper	20 970	799	38102
27	Printing and Publishing	21 738	62	2840
28	Chemicals	42 148	2911	69066
30	Rubber	12 759	127	9954
31	Leather, Shoes	5 169	22	4256
32	Stone, Clay	14 449	836	57859
	(Iron and Steel)	(27 410)	(2340)	(85370)
	(Non-Ferrrous Primary Metals)	(19 321)	(451)	(23342)
33	Primary Metals	46 731	2791	59725
34	Fabricated Metals	34 578	228	6594
35	Nonelectrical Machinery	48 477	198	4084
36	Electrical Machinery	43 361	180	4151
37	Transportation Equipment	68 512	251	3664
38	Instruments	9 907	28	2826
39	Miscellaneous	17 579	58	3299
	Total,Excl.Petroleum Refining	535 355	9655	18035
29	Petroleum Refining	22 043	.	.
	Grand Total	557 398	.	.

Note: Data in BTU per $ gross output compiled from [12] multiplied with the corresponding values of gross output from the US Census of Manufactures for 1967 as reproduced in the US *Statistical Abstract* [5].

Table 16. USA Useful Fuel and Electricity Used in Manufacturing Industries, by Processes, in 1967; After Brookhaven BNL 110.

Manufacturing Industries US SIC Code	Fuel and Electricity used by Process:								
	Ore Reduction	Chem. Feedstock	Heat and Power						Total All Processes
			Motive Power	Process Heat	Water Heat	Space Heat	Air-conditioning	Electric Power	
	10^{12} BTU	10^{12} BTU	10^{12} BTU	10^{12} BTU	10^{12} BTU	10^{12} BTU	10^{12} BTU	10^{12} BTU	10^{12} BTU
20 Food,Beverages	-	-	-	468	1	53	5	88	615
21 Tobacco	-	-	-	4	.	2	5	.	11
22 Textiles	-	-	-	115	22	18	-	60	215
23 Apparel	-	-	-	56	-	8	-	8	72
24 Lumber	-	-	-	108	1	44	-	37	191
25 Furniture	-	-	1	16	1	27	-	15	60
26 Paper	-	3	1	695	-	14	4	82	799
27 Printing	-	-	1	6	1	34	1	19	62
28 Chemicals	-	1064	-	1433	-	33	37	344	2911
30 Rubber	-	77	-	34	-	8	1	7	127
31 Leather, Shoes	-	-	-	10	-	8	-	4	22
32 Stone,Clay	4	-	2	695	1	38	4	92	836
(Iron and Steel)	(1406)	-	-	(745)	-	(26)	(2)	(161)	(2340)
(Non-Ferr.Metals)	(5)	-	-	(255)	-	(11)	(1)	(179)	(451)
33 Primary Metals	1411			1000	-	37	3	340	2791
34 Fabr.Metals	2	-	1	142	1	38	2	42	228
35 Nonelec.Machin.	1	-	-	99	1	48	6	43	198
36 Electr.Machin.	-	-	1	48	-	56	20	55	180
37 Transp.Eq.	2	-	2	108	-	54	14	71	251
38 Instruments	-	-	-	6	-	13	3	6	28
39 Miscellaneous	-	-	1	13	1	27	1	15	58
Total,Excl.Petroleum and Coal	1420	1144	11	5056	30	560	106	1328	9655

Note: Data from [12] in BTU per $ gross output. The coefficients (BTU per $ gross output) were multiplied with the gross output values from the US Census of Manufactures as reproduced in the US *Statistical Abstract* [5].

Table 17. USA Percentage Structure of Useful Fuel and Electricity Used by Processes, in Manufacturing Industries, in 1967; After Brookhaven BNL 110.

Manufacturing Industries US SIC Code	Total BTU used	Processes in Percent								
		Ore Reduction	Chem. Feedstock	Motive Power	Process Heat	Water Heat	Space Heat	Air-condition	Electric Power[a]	Total
	10^{12} BTU	%	%	%	%	%	%	%	%	%
20 Food,Beverages	615	.	.	.	76.2	0.2	8.6	0.8	14.2	100.0
21 Tobacco	11	.	.	0.4	39.4	0.4	15.0	41.2	3.6	100.0
22 Textiles	215	.	.	.	53.5	10.2	8.4	.	27.9	100.0
23 Apparel	72	.	.	.	77.8	.	11.1	.	11.1	100.0
24 Lumber	191	.	.	0.7	56.1	0.5	23.2	0.1	19.4	100.0
25 Furniture	60	.	.	1.4	27.1	0.9	45.7	.	24.9	100.0
26 Paper	799	.	0.4	0.1	86.9	.	1.8	0.5	10.3	100.0
27 Printing	62	.	.	1.8	10.2	1.1	54.5	2.1	30.3	100.0
28 Chemicals	2911	.	36.6	.	49.2	.	1.1	1.3	11.8	100.0
30 Rubber	127	.	60.6	.	26.8	.	6.3	0.8	5.5	100.0
31 Leather, Shoes	22	.	.	.	45.4	.	36.4	.	18.2	100.0
32 Stone,Clay	836	0.5	.	0.2	83.2	0.1	4.5	0.5	11.0	100.0
(Iron and Steel)	(2340)	(60.1)			(31.8)		(1.1)	(0.1)	(6.9)	(100.0)
(Non-Ferr.Metals)	(451)	(1.1)	.	.	(56.6)	.	(2.4)	(0.2)	(39.7)	(100.0)
33 Primary Metals	2791	50.6	.	.	35.8	.	1.3	0.1	12.1	100.0
34 Fabr.Metals	228	0.9	.	0.4	62.3	0.4	16.7	0.9	18.4	100.0
35 Nonelec.Machin.	198	0.5	.	.	50.0	0.5	24.2	3.0	21.8	100.0
36 Electr.Machin.	180	.	.	0.6	26.7	.	31.1	11.1	30.5	100.0
37 Transp.Eq.	251	0.8	.	0.8	43.0	.	21.5	5.6	28.3	100.0
38 Instruments	28	.	.	.	21.4	.	46.4	10.7	21.5	100.0
39 Miscellaneous	58	.	.	1.5	22.6	0.9	48.2	1.5	25.3	100.0
Total,Excl.Petroleum and Coal	9655	14.7	11.8	0.1	52.5	0.3	5.8	1.0	13.8	100.0

a = This electric power may be understood as "non-substitutable" electricity.

Note: Data [12] are taken from Table 15.

Table 18. USA Purchased Fuels and Electricity Used for Heat and Power by Manufacturing Industries 1954-1976; After Census and Annual Survey of Manufactures.

US SIC Code	Manufacturing Industries	1954		1958		1962		1967		1971		1974		1975		1976	
		Total	Electr. Energy Purch.	Total	Electr. Energy Purch.	Total	Electr. Energy Purch.	Total	Electr. Energy Purch.	Total	Electr. Energy Purch.	Total	Electr. Energy Purch.	Total	Electr. Energy Purch.	Total	Electr. Energy Purch.
		10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh	10^9kWh
20	Food, Beverages	236.0	12.0	224.5	15.8	235.2	19.0	263.7	24.4	302.2	35.4	280.2	36.9	268.8	38.4	277.1	39.6
21	Tobacco	3.6	0.2	3.9	0.3	3.9	0.4	5.7	0.7	5.5	0.9	5.9	1.0	5.5	1.1	5.9	1.1
22	Textiles	73.8	11.0	66.6	11.9	73.2	14.1	92.4	20.3	106.6	24.9	94.5	26.9	90.0	26.6	97.0	28.1
23	Apparel	7.9	0.9	10.0	1.7	9.7	2.2	13.8	3.6	19.4	5.5	19.0	6.4	16.4	6.8	16.7	6.8
24	Lumber	29.8	3.2	26.4	3.4	34.5	4.5	55.0	7.4	66.6	9.3	79.6	14.8	67.2	14.4	72.8	15.7
25	Furniture	9.5	1.1	10.0	1.4	10.7	1.7	13.5	2.5	18.1	3.9	15.5[a]	4.1	13.6	3.9	14.0	4.0
26	Paper	190.0	10.8	236.3	12.5	272.2	17.0	338.9	25.9	385.5	35.0	390.0	40.9	354.6	39.2	380.8	43.5
27	Printing	8.5	1.7	12.0	3.0	14.5	4.0	19.4	5.8	30.6	9.6	26.5	9.0	25.5	10.0	25.8	10.1
28	Chemicals	374.1	46.2	451.9	85.6	550.1	90.4	721.0	95.4	814.2	99.6	889.9[a]	124.2	814.7	128.0	876.5	140.3
30	Rubber	33.0	4.0	35.9	4.8	41.9	6.7	53.6	10.2	68.0	16.4	74.7	19.0	66.5	18.8	68.8	19.7
31	Leather, Shoes	8.6	0.6	9.4	0.8	9.3	0.9	9.8	1.3	10.0	1.7	6.7	1.5	6.6	1.7	6.6	1.6
32	Stone, Clay	265.3	9.2	277.0	12.1	309.5	15.5	360.1	19.6	382.3	24.8	391.5	28.9	339.8	27.8	356.3	29.4
33	Primary Metals	533.5	47.4	518.5	50.7	674.8	71.3	709.9	109.5	717.8	122.4	774.0	163.3	654.9	136.6	696.5	147.9
34	Fabr. Metals	52.7	5.9	55.6	7.1	62.5	8.9	87.3	14.7	103.1	20.3	120.6	25.2	107.6	24.4	111.3	25.7
35	Nonelec.Machin.	99.0	12.7	61.6	7.6	69.0	10.3	91.3	16.7	107.6	22.3	107.8	26.1	96.8	27.5	97.1	28.1
36	Electr.Machin.			41.2	7.9	50.8	12.0	68.9	19.0	80.2	23.6	73.5	24.6	66.7	23.7	69.0	23.7
37	Transp.Eq.	73.6	11.1	77.8	13.4	86.9	17.5	107.1	23.5	113.9	27.5	109.9	28.4	101.9	27.6	109.1	29.5
38	Instruments	7.9	0.7	9.4	1.1	11.4	1.7	15.4	2.5	20.1	3.6	20.8	4.6	20.4	5.2	21.6	5.2
39	Miscellaneous	23.9[b]	2.5[b]	16.9[b]	2.2[b]	19.7[b]	3.2[b]	26.1[b]	6.4[b]	31.7[b]	7.4[b]	15.0	3.9	13.0	4.0	13.5	3.8
	Total, Excl. Petroleum and Coal Products	2030.7	181.2	2144.9	243.4	2539.8	301.3	3052.9	409.3	3383.4	494.1	3495.0	589.7	3130.5	565.7	3316.4	603.8
29	Petr.& Coal Prod.	189.5	5.9	273.0	9.5	335.5	12.7	408.5	18.2	467.0	23.7	454.1[a]	27.2	397.8	26.4	387.3	27.8
20-40	All Manuf. Ind.	2220.2	187.1	2417.9	252.9	2875.3	314.0	3461.4	427.5	3850.4	517.8	3949.4	616.9	3528.2	592.1	3708.7	631.6

a = Revised
b = Including Ordnance (SIC 19)

Sources: US *Census of Manufactures*, 1972; Special Reports Series MC72 (SR-6) issued July 1973, Table 6 [ ]
US *Annual Survey of Manufactures*, 1975 and 1976; M75(AS 4-P) issued March 1977 and M76(AS-4P) issued December 1977 [3,4].

Table 19. USA Value Added by Manufacturing Industries, in Current Prices, 1947-1975; After Census and Annual Survey of Manufactures.

US SIC Code	Manufacturing Industries	1947	1954	1958	1962	1967	1971	1972	1973	1974	1975
		10^9\$	10^9\$	10^9\$	10^9\$	10^9\$	10^9\$	10^9\$	10^9\$	10^9\$	10^9\$
20	Food, Beverages	9.1	13.8	17.7	20.9	26.6	34.1	35.6	39.7	44.8	48.1
21	Tobacco	.6	.9	1.4	1.6	2.0	2.6	2.6	2.9	3.2	3.7
22	Textiles	5.3	4.7	5.7	6.0	8.1	10.0	11.7	13.0	13.2	12.1
23	Apparel	4.4	5.2	6.0	7.1	10.0	12.4	13.5	14.6	14.9	13.4
24	Lumber	2.5	3.2	3.2	3.6	4.9	6.8	10.3	12.4	11.5	10.5
25	Furniture	1.3	2.0	2.4	2.8	4.2	5.2	6.1	6.7	7.0	6.3
26	Paper	2.9	4.6	5.7	7.0	9.7	11.7	13.1	15.2	19.1	17.9
27	Printing	4.2	6.4	7.9	10.0	14.3	18.1	20.2	21.9	23.6	24.5
28	Chemicals	5.3	9.5	12.3	16.0	23.6	29.4	32.4	36.2	44.4	45.1
30	Rubber	1.3	1.9	3.3	4.3	6.8	9.5	11.6	13.4	14.8	13.7
31	Leather, Shoes	1.5	1.6	1.9	2.1	2.6	2.8	2.9	3.0	3.1	3.2
32	Stone, Clay	2.3	3.9	5.3	6.6	8.3	10.8	12.6	13.8	14.6	15.3
33	Primary Metals	5.7	9.8	11.5	13.7	20.0	21.1	23.3	28.6	37.3	30.6
34	Fabr. Metals	4.9	7.7	9.4	11.1	18.0	22.0	26.9	30.6	35.2	34.1
35	Nonelec.Machin.	7.8	12.3	12.4	17.3	27.8	30.7	37.6	44.6	52.5	51.5
36	Electr.Machin.	3.9	7.3	10.6	16.4	24.5	27.9	30.6	35.0	36.9	34.8
37	Transp.Eq.	5.8	13.4	15.3	20.9	28.2	34.8	39.8	46.5	45.0	45.2
38	Instruments	1.1	2.1	2.8	3.7	6.4	8.4	10.6	12.2	13.7	14.1
39	Miscellaneous	2.0	2.7	2.7	3.3	10.4	10.2	6.8	7.2	7.7	7.7
	Total,Excl.Petroleum and Coal Products	71.9	113.0	137.5	174.4	256.5	308.5	348.2	397.5	442.5	431.8
29	Petr.& Coal Prod.	.	.	.	.	5.4	.	5.8	7.7	10.0	10.1
20-40	All Manuf.Ind.	.	.	.	.	261.9	.	354.0	405.2	452.5	441.9

Sources: *US Statistical Abstract, 1977 and Earlier Years* [5], standard table "Manufactures Summary for Industry Groups"

Table 20. USA Value Added by Manufacturing Industries, in Constant Prices of 1967, Estimated, 1947-1977

US SIC Code	Manufacturing Industries	1947	1954	1958	1962	1967	1971	1972	1973	1974	1975	1976	1977[a]
		$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$	$10^9$$
20	Food, Beverages	15.6	16.9	19.7	22.4	26.6	30.1	31.1	32.2	33.0	32.7	35.1	36.7
21	Tobacco	.5	.9	1.3	1.6	2.0	2.0	2.1	2.2	2.2	2.2	2.4	2.3
22	Textiles	5.1	4.8	5.9	6.1	8.2	9.6	10.9	11.7	10.9	10.0	11.2	11.2
23	Apparel	4.2	5.3	6.2	7.2	10.0	10.6	11.0	11.8	11.5	10.9	12.3	12.5
24	Lumber	3.4	3.5	3.2	3.9	4.9	5.7	6.1	6.3	5.8	5.4	6.3	6.7
25	Furniture	1.7	2.2	2.4	2.9	4.2	4.9	5.5	6.0	5.8	5.0	5.6	5.9
26	Paper	3.9	5.1	6.0	7.5	9.7	11.8	12.6	13.4	13.2	11.4	13.0	13.5
27	Printing	6.2	9.5	8.6	10.7	14.3	15.4	16.3	17.0	17.0	16.3	17.4	18.0
28	Chemicals	5.2	8.5	11.3	15.8	23.5	29.7	34.0	36.6	37.5	34.7	39.9	42.6
30	Rubber	0.9	2.3	3.4	4.7	6.8	10.1	11.7	12.5	13.3	11.4	13.6	15.8
31	Leather, Shoes	1.8	2.1	2.2	2.3	2.6	2.3	2.3	2.2	2.0	2.0	2.1	2.0
32	Stone, Clay	4.1	5.1	5.9	6.9	8.4	9.2	10.0	11.1	11.0	9.8	11.4	12.1
33	Primary Metals	12.4	12.8	12.4	15.2	20.0	20.0	22.4	25.4	24.6	19.2	21.8	22.0
34	Fabr. Metals	8.9	10.0	10.4	12.6	18.0	18.7	20.2	22.5	22.3	19.8	22.1	23.6
35	Nonelec.Machin.	14.5	16.8	13.9	16.5	27.8	27.8	32.2	37.3	38.9	34.8	37.5	40.3
36	Electr.Machin.	7.3	9.9	11.9	15.6	24.5	26.5	29.9	35.0	35.3	28.7	32.3	34.8
37	Transp.Eq.	8.9	16.0	15.6	24.3	28.2	27.6	30.5	33.5	30.7	27.4	31.3	34.2
38	Instruments	1.6	2.4	3.0	3.9	6.4	7.0	7.7	8.8	9.2	8.4	9.5	10.2
39	Miscellaneous	2.7	3.1	2.9	3.5	10.4	11.3	12.8	13.7	13.9	12.9	14.5	7.2
	Total, Excl. Petroleum and Coal Products	108.9	137.2	146.2	183.6	256.6	280.3	309.3	339.2	338.1	303.0	339.3	351.6
29	Petr.& Coal Prod.	.	.	.	.	5.4	6.3	6.6	7.0	6.8	6.7	7.2	7.6
20-40	All Manuf.Ind.	.	.	.	.	262.0	286.6	315.9	346.2	344.9	309.7	346.5	359.2

a = Preliminary

Sources: 1947-1962 After *Ford Study* [7]
1971-1977 Value Added extrapolated by Federal Reserves industrial production indices, 1967=100.

Table 21. USA Deflators, Value Added by Manufacturing Industries, Estimated, 1947-1975.

US SIC Code	Manufacturing Industries	1947	1954	1958	1962	1967	1971	1972	1973	1974	1975
		Index Numbers, 1967 = 100									
20	Food, Beverages	58.6	81.2	90.0	93.0	100.0	113.3	114.5	123.3	135.8	147.1
21	Tobacco	109.4	100.0	103.9	98.0	100.0	130.0	123.8	131.8	145.5	168.2
22	Textiles	103.6	98.6	97.0	98.6	100.0	104.2	107.3	111.1	121.1	121.0
23	Apparel	103.6	98.6	97.0	98.6	100.0	117.0	122.7	123.7	129.6	122.9
24	Lumber	73.4	92.6	99.1	91.6	100.0	119.3	168.9	196.8	198.3	194.4
25	Furniture	77.0	92.9	99.1	97.7	100.0	106.1	109.1	111.7	120.7	126.0
26	Paper	74.0	89.5	94.5	93.8	100.0	99.2	103.2	113.4	144.7	157.0
27	Printing	67.3	86.4	92.0	93.7	100.0	117.5	123.9	128.8	138.8	150.3
28	Chemicals	102.7	112.0	108.8	101.4	100.0	99.0	95.3	98.9	118.4	130.0
30	Rubber	144.4	95.5	98.1	91.0	100.0	94.1	100.0	107.2	111.3	120.2
31	Leather, Shoes	83.3	77.6	82.9	92.7	100.0	101.2	126.1	136.4	155.0	160.0
32	Stone, Clay	56.0	76.0	90.0	95.1	100.0	117.4	126.0	124.3	132.7	156.1
33	Primary Metals	46.0	76.7	92.4	90.0	100.0	105.5	103.6	112.6	151.6	158.9
34	Fabr. Metals	54.9	76.3	90.4	87.8	100.0	117.6	133.2	136.0	157.8	172.2
35	Nonelec.Machin.	53.7	73.4	89.4	105.0	100.0	110.4	116.8	119.0	135.0	148.0
36	Electr.Machin.	53.7	73.4	89.4	105.0	100.0	105.3	102.3	100.0	104.5	121.3
37	Transp.Eq.	64.1	83.8	98.1	86.0	100.0	126.1	130.5	139.6	146.6	164.6
38	Instruments	67.3	86.4	92.0	93.7	100.0	120.0	137.7	138.6	148.9	167.9
39	Miscellaneous	73.5	86.4	92.0	93.7	100.0	90.3	54.7	51.8	54.7	60.5
	Total, Excl. Petroleum and Coal Products	67.3	82.3	94.0	95.0	100.0	110.1	112.8	117.2	130.8	142.3
29	Petr. & Coal Prod.	.	.	.	.	.	.	87.9	110.0	147.1	150.7
20-40	All Manuf. Ind.	.	.	.	.	.	.	113.5	117.0	131.2	142.7

Sources: 1947-1962 Data compiled from *Ford* and *Project Independence Reports* [7,6], and Wholewale Price Index Numbers.
1971-1975 Deflator implicit in Census, value added at current prices and estimated value added at 1967 prices (see Tables 19 and 20).

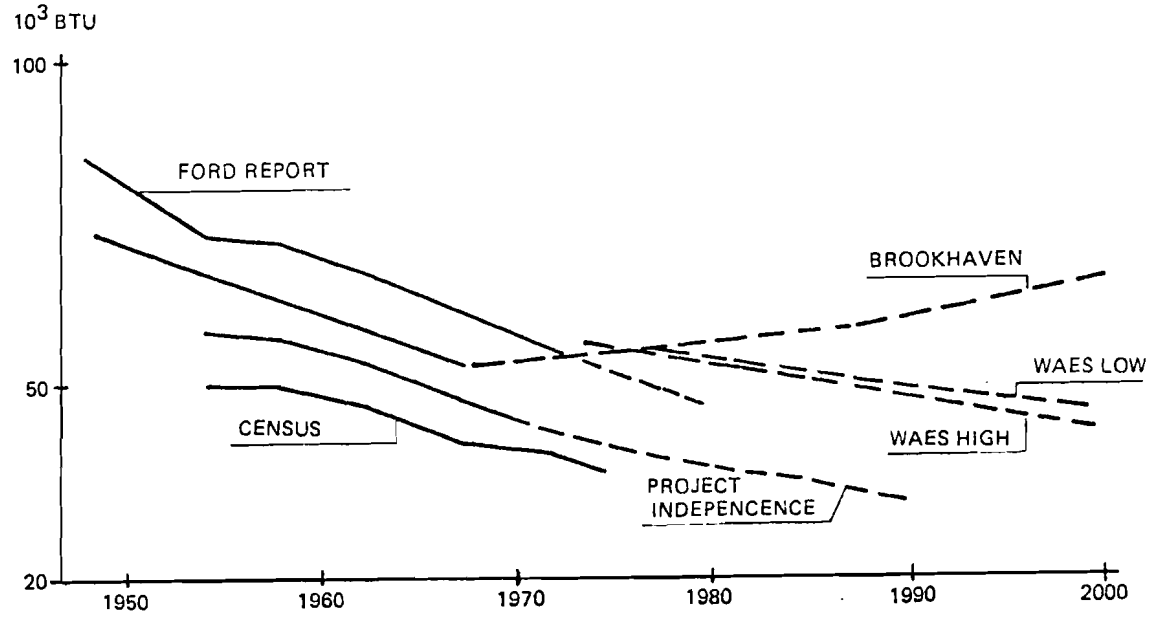

Figure 1. USA Total Manufacturing Excluding Petroleum and Coal Products

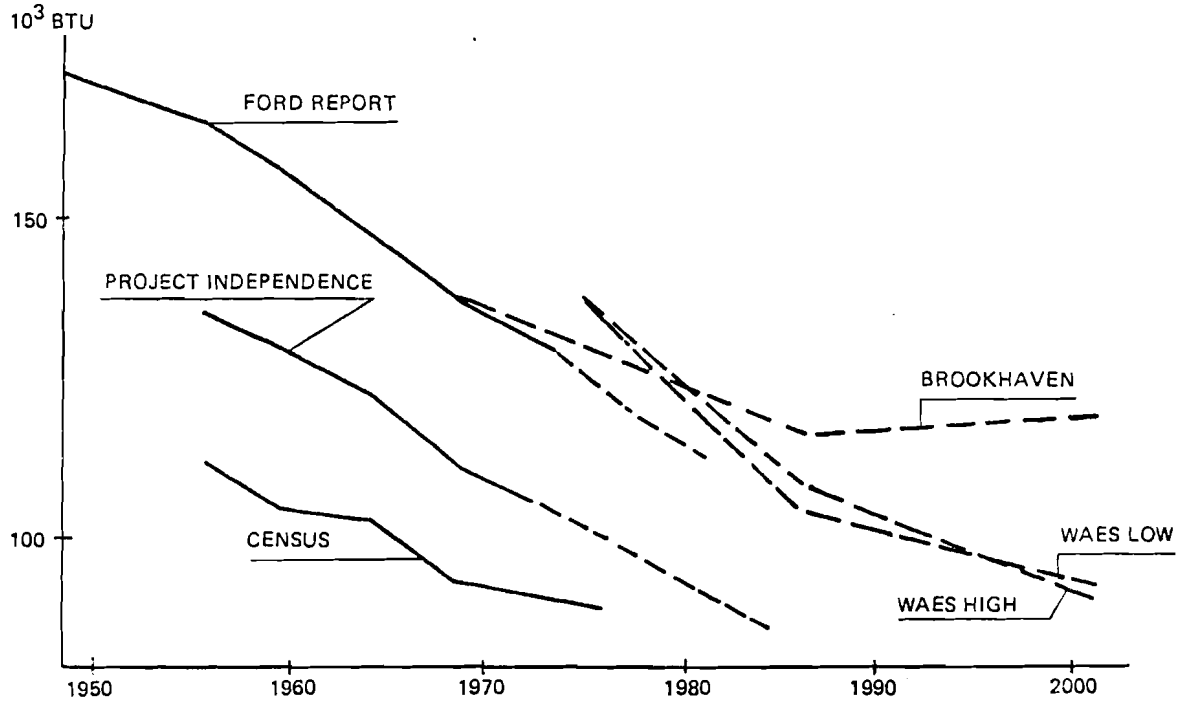

Figure 2. USA Five Energy Intensive Industries Total (Food; Paper; Chemicals; Stone, Clay, and Glass; Metals)

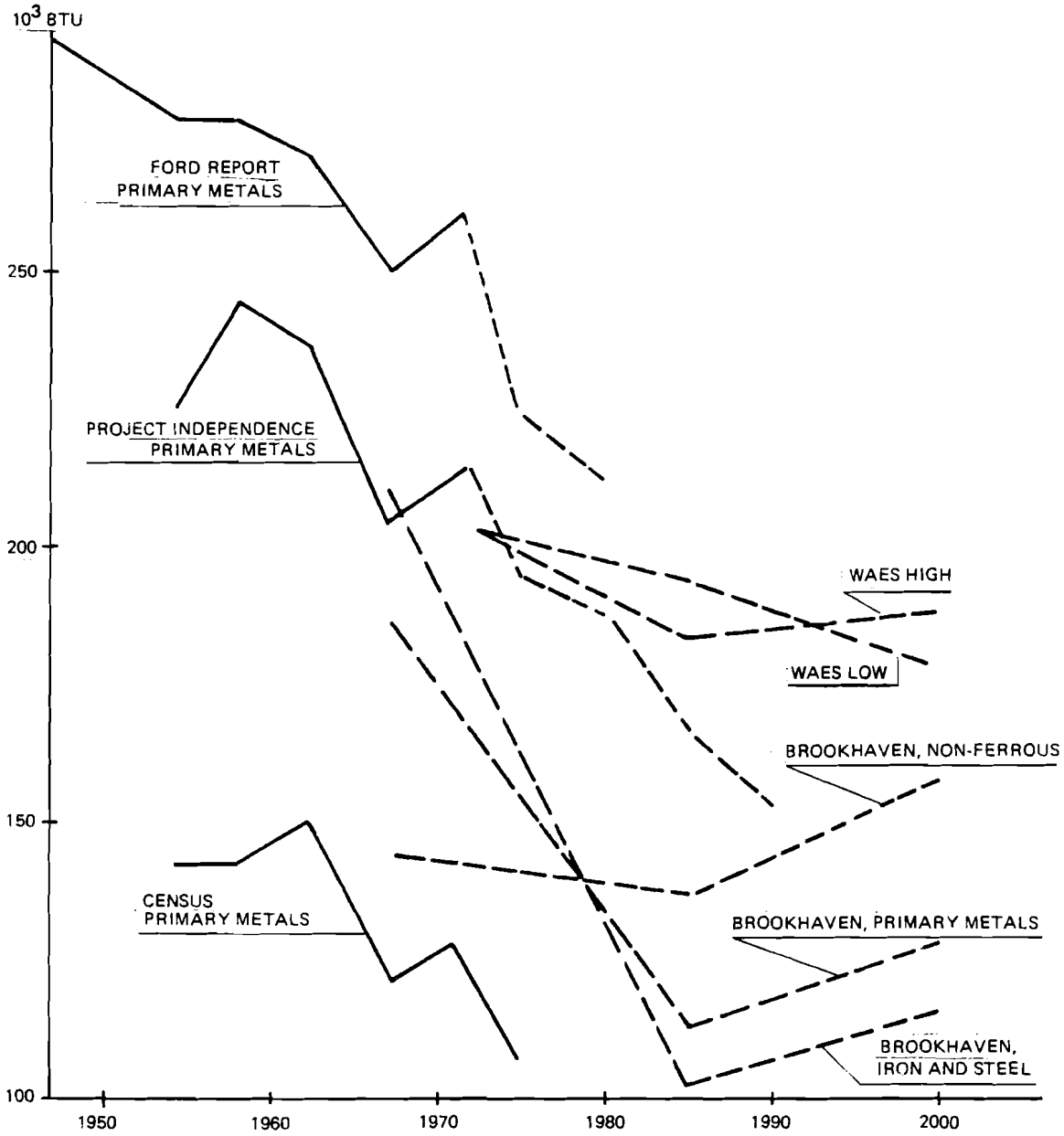

Figure 3. USA Primary Metals Industries

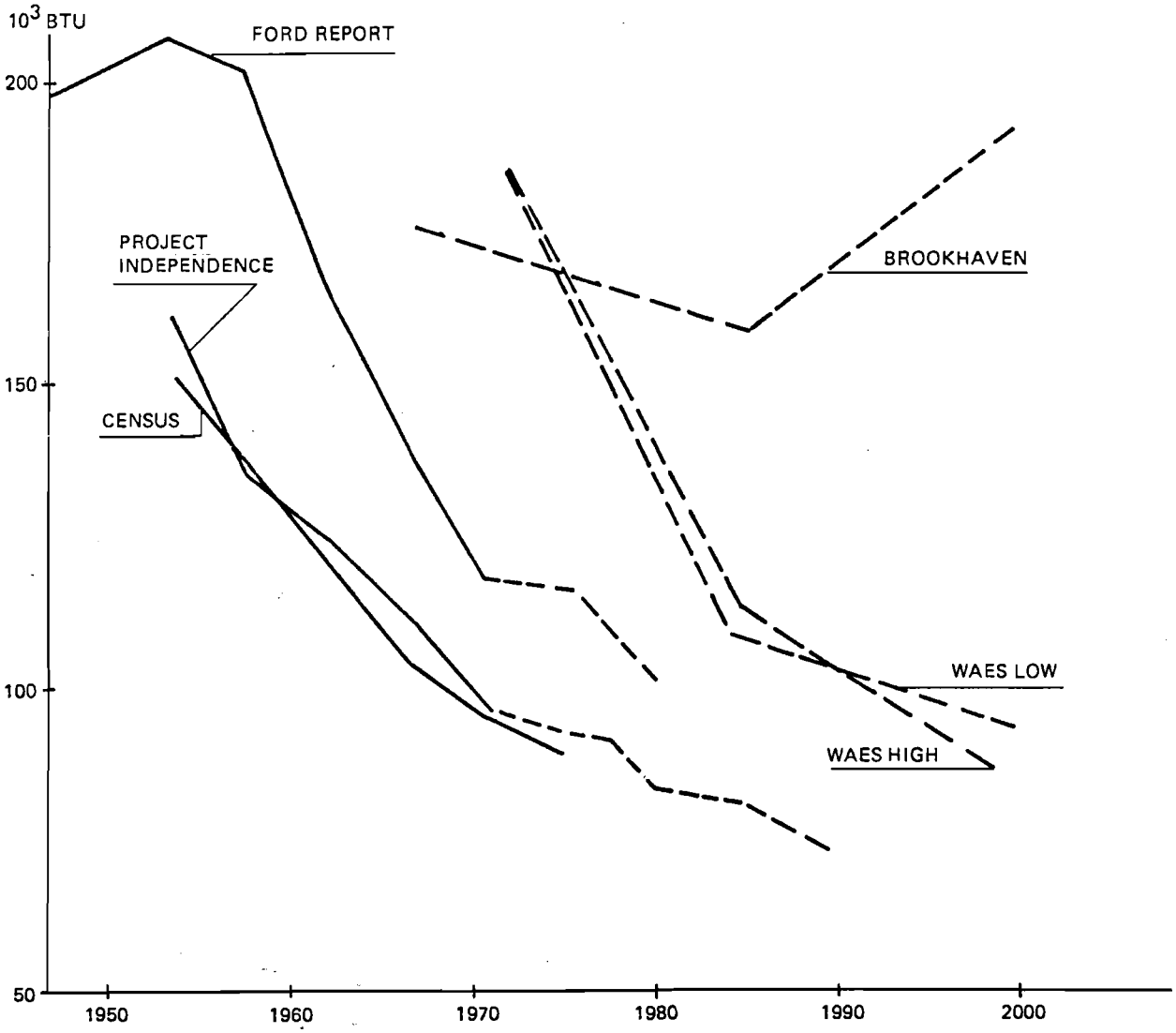

Figure 4. USA Chemicals Industries

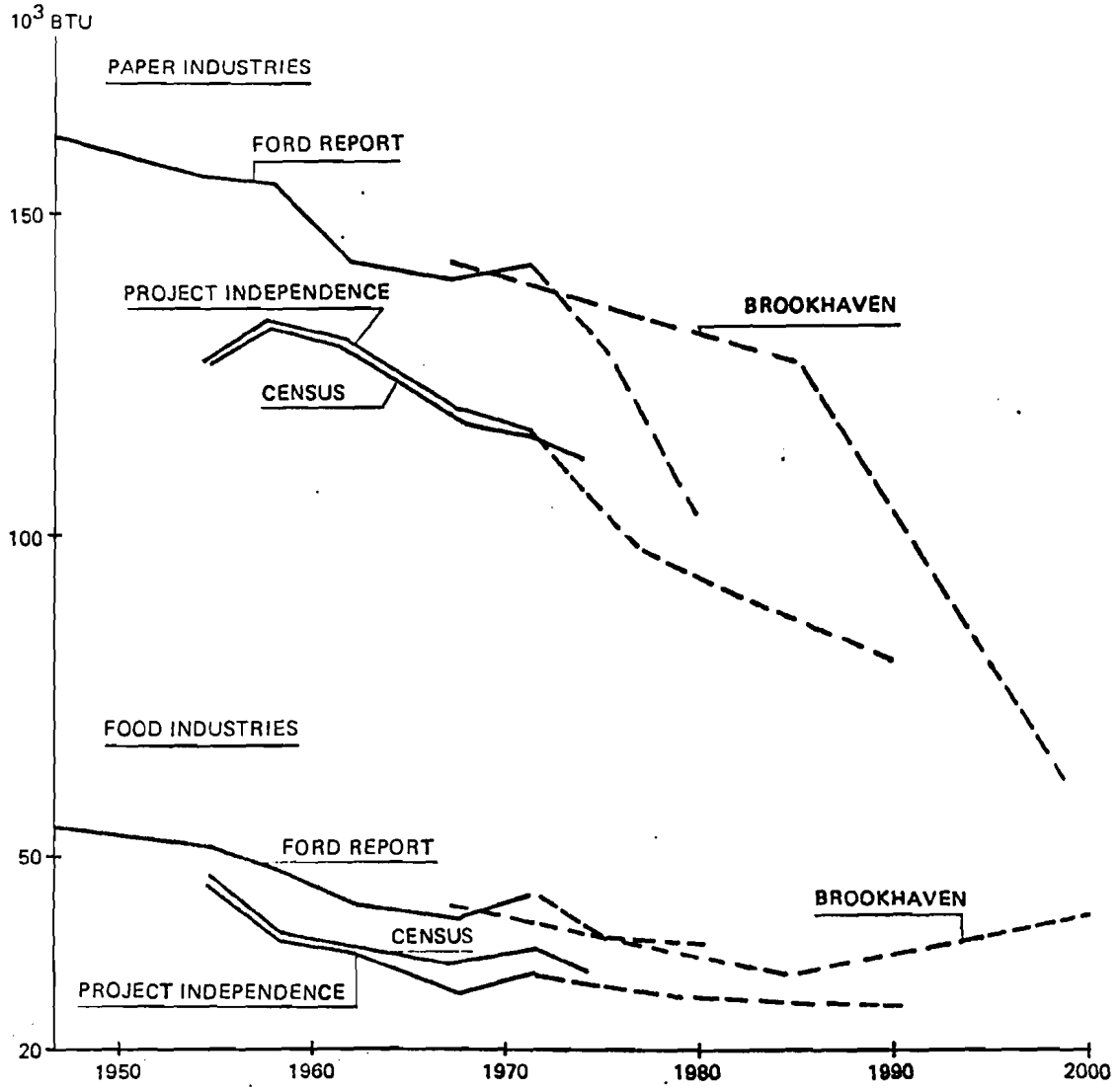

Figure 5. USA Food Industries and Paper Industries

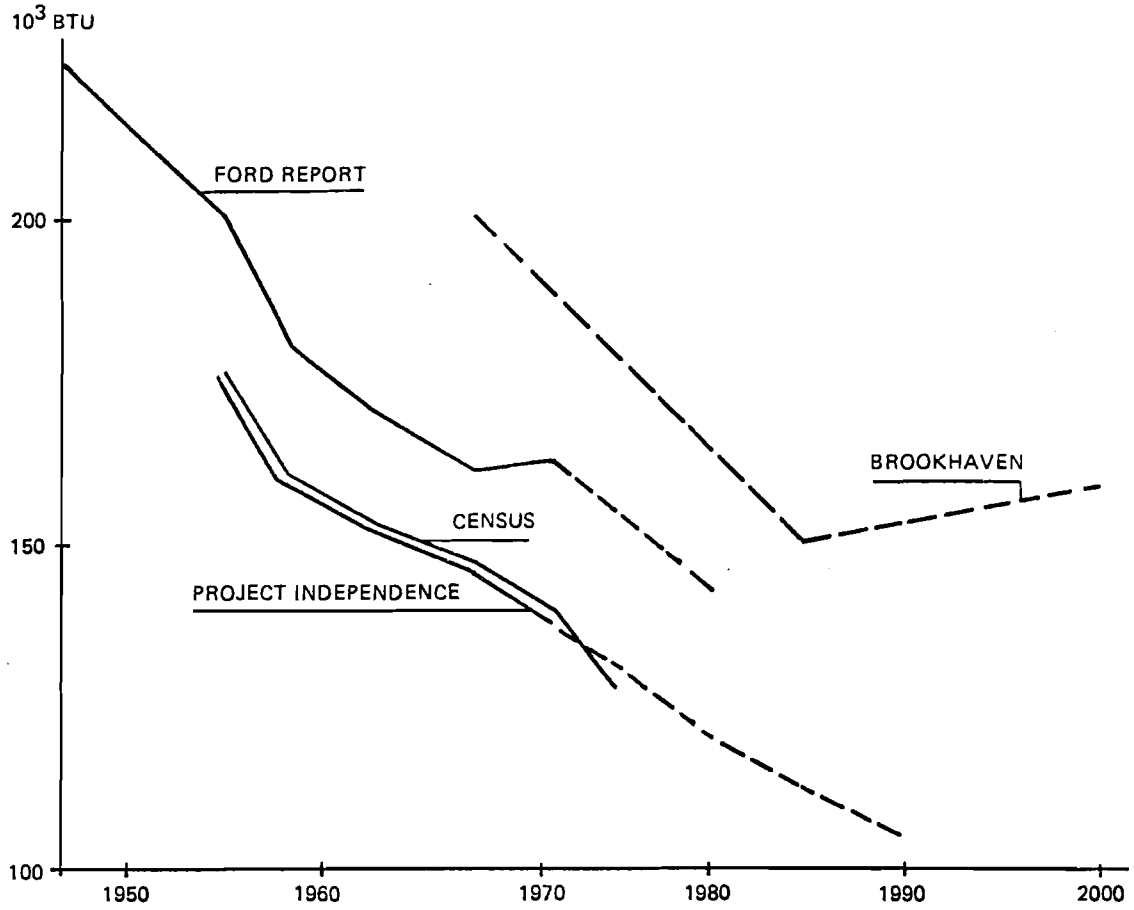

Figure 6. USA Stone, Clay, and Glass Industries