MEASURING ENERGY EFFICIENCY GAINS: METALS FABRICATION

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Have US manufacturers successfully reduced the energy intensity of their production? It depends how intensity (i.e., the ratio of energy consumed per good produced) is measured. Using data on the metals fabrications industries, this paper examines how choice of energy input, production output, and time period impact the measurement of energy intensity changes.

ENERGY INPUTS

Manufacturing establishments consume a variety of energy sources that are either produced offsite and purchased by the firm or produced onsite from conventional or byproduct sources. These sources may be used for heat, power, and electricity generation onsite or consumed as raw materials in the production of finished goods (feedstocks). Which measure of Energy is the most appropriate?

Prior to 1985, only offsite-produced conventional sources purchased by manufacturers were collected by the Bureau of the Census. Measuring energy inputs this way underestimated actual energy consumption by process and materials production industries that utilize waste streams and byproducts in increasing numbers to substitute conventional fuels. Often, these byproducts are valued far below conventional fuels, affording considerable cost savings for the manufacturer.

Since 1985, the measure of energy consumption accepted by EIA's Manufacturing Energy Consumption Survey (MECS) and other data sources has been total inputs for heat, power, and electricity generation. This total inputs measure includes both offsite- and onsite-produced sources used, excluding feedstocks, and is comparable to site energy measured for other end-use sectors. The period of investigation coincides with three recent MECS surveys -- 1985, 1988, and 1991.

In addition to this measure of site energy, primary energy can be estimated by taking into account the losses occurring during the delivery of energy to industrial establishments. Primary energy incorporates the generation, transmission, and distribution losses for electricity on a regional basis to account for variations in the generation mix and power pool use. The primary energy estimate also includes a gross estimate of distribution losses in natural gas. Appendix A describes the derivation of primary energy.

This paper focuses on metals fabricators, those facilities in standard industrial classification (SIC) codes 34-37. Specifically included are manufacturers of fabricated metal products (SIC 34), industrial machinery and equipment (SIC 35), electronic and other electric equipment (SIC 36), and transportation equipment (SIC 37). These four groups consumed 1,069 trillion Btu of site energy in 1991, representing only 7 percent of all manufacturers. Metals fabrication establishments produce insignificant amounts of onsite byproducts for use to power operations and use equally insignificant amounts of energy feedstocks. As shown in Table 1, metals fabricators depended on electricity and natural gas for 85 percent of their site energy requirements in 1991.

During the six years under study, metals fabricators have become increasingly electric-intensive. Site electricity consumption grew by 4 percent during 1985-1991, while total site consumption barely grew by 1 percent. When primary energy is considered, electricity grew by 6 percent, and electricity and natural gas accounted for 92 percent of total primary demand in 1991.

Table 1. Energy Input Measures for US Metals Fabricators, 1985-1991

Energy/Source	Trillion Btu			Percent Change		
	1985	1988	1991	1985-1988	1988-1991	1985-1991
Site Energy Total	1,056	1,183	1,069	12.0	-9.6	1.3
Electricity	406	456	423	12.2	-7.2	4.1
Natural Gas	486	554	494	13.8	-10.8	1.5
Primary Energy Total	2,080	2,360	2,164	13.5	-8.3	4.0
Electricity	1,421	1,622	1,508	14.2	-7.1	6.1
Natural Gas	496	565	504	13.8	-10.8	1.5

Source: Energy Information Administration, *Manufacturing Energy Consumption Survey* 1985 and 1988, Table 3 calculated, and 1991 Table A38.

Most of the growth in site energy consumption (12 percent) occurred during 1985-1988 when the economy was growing (GNP grew 3.3 percent versus 0.7 percent during 1988-1991). During the next three years, as the economy entered a recession, site energy demand reversed earlier trends and shrank by 10 percent. Since the recessionary period almost canceled out all demand increases during 1985-1988, it appears to make sense examining changes in energy and output over two distinct periods.

For the purposes of sector-specific analysis, site energy provides the most realistic appraisal of actual changes in relative demand. When viewed from a macroeconomic perspective, primary energy makes sense, otherwise changes in primary energy incorporate improvements in the transformation of electricity that are not attributable to the industrial sector directly. Changes in energy consumption only reveal part of the picture. If energy intensity is the measure to examine, then some denominator representing production or output is necessary.

PRODUCTION OUTPUTS

There is no physical measure of output consistently available across all industry groups, let alone with a major industry group (two-digit). For example, Industrial Machinery and Equipment (SIC 35) produces a tremendous variety of machinery and equipment, including power-driven hand tools, metal cutting and forming machines, computer terminals, robotics, HVAC equipment, automotive components, and industry-specific machinery (e.g., highway construction, oil and gas fields, food processing, textiles, papermaking, etc.). There is no single product line, and each unique product involves different process steps and energy requirements. In addition, the size and weight of the output varies significantly. As a result, physical output cannot be measured either by the number of units or weight.

Instead, monetary-based indicators are used as a surrogate for production output. These values change over time, due to inflation and variations in customer demand. Increased value does not necessarily indicate an increase in actual production. To compensate for inflation-induced price fluctuations, all values are reported in constant 1987 dollars. Even in constant dollars, these values can fluctuate due to changes in product prices, energy prices, cost of capital, domestic and international taxes, changes in consumer demand, macroeconomic trends, production downturns.

A variety of dollar-denominated surrogate output measures are reported by the Bureau of Economic Analysis, Bureau of the Census, Federal Reserve Board, and Bureau of Labor Statistics. These include: Gross Output, Value of Shipments, Value of Production, Industrial Production, Value Added, and Gross Product Originating. Which measure of output is most appropriate?

Gross Output: The most comprehensive measure of production, according to the Bureau of Economic Analysis (BEA), is the measure of sales or receipts and other operating income, plus inventory change. More specifically, gross output equals manufacturing shipments, plus change in business inventories, minus cost of resale, plus coverage adjustment, plus commodity taxes, plus new force account construction (value of construction undertaken with own labor, capital, etc.). The shipments and inventory data are Census-based but adjusted by BEA at the 5-digit SIC level to correct for drift between *Annual Survey of Manufactures* and *Census of Manufactures* (ASM 2-3 percent below Census). BEA estimates the other components from its National Income and Products Accounts and input-output tables. All components are deflated to 1987 dollars before being summed to gross output.

Value of Shipments: The Bureau of the Census collects in the *Annual Survey of Manufactures* the value of received or receivable net sales (exclusive of freight and taxes) of all primary and secondary products shipped, as well as all miscellaneous receipts for contract work performed for others, installation and repair, sales of scrap, and sales of products bought and resold without further processing. The series used in MECS has been corrected to SIC 1987 basis in all years,[1] adjusted by MECS weights[2] (given sample size), and deflated to constant 1987 dollars. This measure is used by MECS in all recent reports and articles.

Value of Production: Because of inventory fluctuations and other practices used by manufacturers to meet consumer demand, value of shipments is not indicative of true production. A proxy for the value of production is calculated as the value of shipments plus inventory change during the year (subtract prior year-end from current year-end inventories) in constant 1987 dollars.

Value Added: The Census calculates the value added by manufacture in each *Annual Survey of Manufactures* by subtracting from the value of shipments all purchases that can be measured, i.e., the cost of materials, supplies, containers, purchased fuel and electricity, and contract work. This calculation is adjusted by adding the value added by merchandising (mark-up) and the net change in finished goods and work-in-progress inventories. For industries in which value of production is collected instead of value of shipments, value added is adjusted by the change in work-in-progress inventories. We deflated value added to 1987 constant dollars using Gross Product Originating deflator. The problem with value added by manufacture, as measured by the Census, is that it includes the value of services purchased that many economists feel should be removed, i.e., photocopying, telephone bills, sewer/toxic waste disposal, advertising, temporary employees, computer software, rentals, etc.

Industrial Production: The Federal Reserve Board (FRB) calculates an industrial production index by compiling indices of physical output from a variety of agencies and trade groups, then weighting each 4-digit SIC index by the Census' value added, and adding to it the cost of materials for each, all deflated. When physical output measures are not available, FRB uses the number of production workers or amount of electricity used as the basis for the index. This is a linked Laspeyres index with shifting weights every 5 years (coinciding with Censuses in 1982, 1987, 1992, etc.) The index is set at 1987=100 and there has been no attempt to standardize the SIC definitions before and after 1987. To convert this index into dollars (for intensity measure purposes), FRB provided its estimate of "real value added" in 1987 to be multiplied against the index. This is the measure of industrial activity used by Lee Schipper in his recent book, *Energy Efficiency and Human Activity*.

Gross Product Originating (GPO): The BEA defines GPO as the contribution of each industry to gross domestic product (GDP). GPO is equal to an industry's gross output (sales or receipts and other operating income, plus inventory change) minus its intermediate inputs (consumption of goods and services purchased from other industries or imported). GPO is actually calculated by summing National Income and Product Accounts components--wages and salaries, capital, profits, etc.--and corresponds in concept to value added.

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[1] In 1987, SIC altered the classification of certain establishments, affecting metals fabricators. Redefinition of certain facilities resulted in a structural shift in 1987; data collected prior were based on a 1972 SIC scheme while all data collected after 1987 were based on the 1987 SIC.

[2] Census and MECS surveys are based on a different number of respondents: the Annual Survey of Manufacturers is mailed to 55,000 while MECS is sent to 16,000 establishments. The variation in value of shipments can be corrected by multiplying the estimates by weights representative of the MECS respondents.

Current dollar estimates are converted into 1987 constant dollars using fixed 1987 weights in the double deflation technique; however, different SIC classifications are evident in this series (SIC 1972 for years 1972-1987 and SIC 1987 afterwards). This is the measure the Office of Technology Assessment used in its recent study, *Industrial Energy Efficiency*, and the Bureau of Labor Statistics (BLS) uses in its Multifactor Productivity work.

Comparing All 6 Measures

Table 2 identifies the differences in measures of change in demand or output. There is no consistent difference, rather different measures yield different results depending on the industry or group. The output measures range from 354 to 903 billion 1987 dollars in 1991. They are ordered by magnitude in Table 2, with gross output representing the most comprehensive value and gross product originating representing only 40 percent of the dollar value of gross output. The six measures reflect the growth and recessionary periods evident in GNP. Only value added by manufacture (Census) is very different from the other 5 measures in that it does not reflect the economic contraction apparent in 1988-1991. As a result, value added appears to grow faster than the other surrogate production measures.

Table 2. Output Measures for US Metals Fabricators, 1985-1991

Output Surrogates	Billion 1987 Dollars			Percent Change		
	1985	1988	1991	1985-1988	1988-1991	1985-1991
Gross Output	859	924	903	7.6	-2.2	5.2
Value of Shipments	821	938	876	14.3	-6.6	6.7
Value of Production	768	950	869	23.7	-8.5	13.1
Value Added	406	464	482	14.1	3.9	18.6
Industrial Production	388	460	453	18.4	-1.4	16.7
Gross Product Originating	328	365	354	11.1	-3.0	7.8

Sources: Bureau of the Census, *Annual Survey of Manufactures 1985, 1988, & 1991*, *Federal Reserve Statistical Release*, 8/15/94, Robert Parker, "Gross Product by Industry, 1977-90," *Survey of Current Business*, May 1993, p. 33-54, unpublished BEA and EIA data.

In terms of percent change, ignoring value added, the surrogate output measures cover a range from 8 to 24 percent growth in 1985-1988 and 1 to 8 percent reduction in 1988-1991. The smallest variation was experienced by the largest output measure -- gross output. The largest variation occurs in the value of production measure. In 1985-1988, the 24 percent growth is primarily due to a huge stock drawdown in 1984-1985, compensating for very low production levels in 1985. A stockbuild prior to 1988 was again reversed as inventories were again depleted in 1991 to accommodate demand.

Depending on the measure, metals fabricators contributed from 33 to 39 percent of total output in 1991. The relative share of metals fabricators is highest for GPO. Their businesses contribute substantial value added to products manufactured by primary metals industries. Most of their production is driven by the demand for automobiles, defense vehicles, transportation infrastructure, telecommunications, electric utilities, and computers. Two measures -- value of shipments and GPO -- appear to represent industrial movement most closely, capturing the shrinking contribution of metals fabricators by 1991. In addition, the value of shipments measure presented here has been corrected for shifting among SICs when the basis was revised in 1987. Only electronic and other electric equipment manufacturers managed to maintain market share during this period. All other metals fabricators, led by transportation equipment manufacturers, lost valuable output.

INTENSITY MEASURES

One of the goals of business is to produce as much output as possible without increasing the consumption of energy and other inputs. If output increases, but the amount of energy consumed stays constant or decreases, then production is said to be less energy intensive. Likewise, if output remains constant, but the amount of energy consumed falls, then production is said to be less energy intensive. Reductions in energy intensity are not always accompanied by increases in energy efficiency, as behavioral or other structural effects may explain such movements. Two behavioral effects that can be examined in manufacturing are management's handling of inventory and capacity utilization.

Inventory behavior has been addressed in the development of the value of production measure. The impact of inventory adjustments is revealed in Table 2, where stock behavior resulted in larger percent changes in output than was measured purely in terms of value of shipments. This exaggerating effect impacts energy intensity measures as presented in Table 3. During 1985-1988, the greater growth in value of production yielded a larger reduction in energy intensity (-9.4 versus -1.9 percent value of shipments). During 1988-1991, a greater reduction in value of production yielded a smaller change in energy intensity (-1.2 versus -3.2 percent per dollar value of shipments).

Table 3. Site Energy Intensity Measures for US Metals Fabricators, 1985-1991

Energy Intensity per	Thousand Btu/1987 Dollar			Percent Change		
	1985	1988	1991	1985-1988	1988-1991	1985-1991
Gross Output	1.23	1.28	1.18	4.1	-7.6	-3.7
Value of Shipments	1.29	1.26	1.22	-1.9	-3.2	-5.1
Value of Production	1.37	1.25	1.23	-9.4	-1.2	-10.5
Value Added	2.60	2.55	2.22	-1.8	-13.0	-14.6
Industrial Production	2.72	2.57	2.36	-5.3	-8.3	-13.2
Gross Product Originating	3.22	3.24	3.02	0.8	-6.8	-6.1

Source: Calculated from Tables 1 and 2.

Capacity utilization rates are reported by the FRB for key industries. The rates follow economic growth assumptions; rates were down in 1991 while 1988 was a banner year with almost all metals fabricators utilizing 80 percent of their capacity. Capacity utilization is addressed in the EIA report in more detail.

As shown in Table 3, site energy intensities varied considerably. Energy per dollar value of gross output appears to be out of synch with the other measures, showing a 4 percent increase in energy intensity during 1985-1988. All other measures show almost flat to 9.4 reduction in energy intensity during the same three years. Disregarding the outliers leaves value of shipments and GPO as the two most reasonable measures.

Metals fabricators are the least energy-intensive manufacturers in the US, regardless of the measurement used. Process industries are ten times as energy intensive as metals fabricators and the primary metals establishments that provide the fabricators with their raw materials are 30 times as energy intensive. It is surprising then that the metals fabricators should register the largest reductions in energy intensity in the late 1980s. During 1988-1991, metals fabricators reduced site energy intensity by 6.9 percent if measured per dollar value GPO and 3.3 percent if measured per dollar value of shipments. By contrast, the entire manufacturing sector registered a 1.3 percent reduction per GPO and a 3.4 percent increase per value of shipments. Much of the difference in site energy intensities can be explained by the greater reduction in site energy consumption by metals fabricators relative to reductions in output and other industries' energy consumption.

Metals fabricators have had success in reducing their energy use despite increasing electricity intensity by participating in a number of programs targeting energy efficiency improvements. One such program is the Energy Analysis and Diagnostic Centers (EADC) which has been offering free audits to small and medium-sized manufacturing facilities since the early 1980s. Metals fabricators received 33 percent of the audits performed through November 1994, according to a data base maintained by Rutgers University. A total of 6,174 audit recommendations were made to metals fabricators, primarily to fabricating metals and industrial machinery plants. Over half of the recommendations are housekeeping in nature, and relate to electricity use in lighting and motors. Metals fabricators can realize significant energy savings by simply performing some of the following steps:

- Utilize higher efficiency, low-wattage lamps
- Eliminate leaks in the gas and compressed air lines and valves
- Moving the air compressor to a cooler location in the plant
- Install timers or thermostats
- Insulate bare equipment

Other recommendations involve investing in high-efficiency equipment, such as improved belts, electric motors, and new light sources.

Energy intensity values are almost doubled when calculated for primary energy consumption (see Table 4). When site energy intensity is reduced, the magnitude of the percent change is smaller if primary energy is used. This means that greater electricity use by metals fabricators explains part of the change in site energy intensity. The opposite is true in cases of increased site energy intensity. Greater electricity intensity contributes 1.3 percent over site energy intensity during each of the periods, for a total of 2.6 percent during 1985-1991, whether measured per GPO or value of shipments. Presenting primary energy intensity measures alone would inflate the percent changes without adequately explaining what a large portion of the change actually represents. Providing the site energy intensity measures, along with the contribution of greater electricity use, helps to explain the meaning of the numbers.

Table 4. Primary Energy Intensity Measures for US Metals Fabricators, 1985-1991

Energy Intensity per	Thousand Btu/1987 Dollar			Percent Change		
	1985	1988	1991	1985-1988	1988-1991	1985-1991
Gross Output	2.42	2.56	2.40	5.5	-6.3	-1.1
Value of Shipments	2.53	2.52	2.47	-0.7	-1.9	-2.5
Value of Production	2.71	2.48	2.49	-8.2	0.2	-8.1
Value Added	5.12	5.09	4.49	-0.6	-11.8	-12.3
Industrial Production	5.35	5.13	4.77	-4.1	-7.0	-10.9
Gross Product Originating	6.33	6.47	6.11	2.1	-5.5	-3.5

Source: Calculated from Tables 1 and 2.

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APPENDIX A - CALCULATION OF PRIMARY INDUSTRIAL ENERGY CONSUMPTION

Information on losses is not available for all energy sources.[3] Electric utilities, and by association, nonutility generators, can fully measure their generation and T&D losses by fuel input (i.e., fossil fuel, nuclear, hydropower, and geothermal). Natural gas T&D losses are more difficult to measure since they are pipeline specific. Energy losses in pipeline, marine, and truck transportation as well as in bulk storage and distribution facilities have not been quantified for either petroleum or coal products.

Annual primary conversion factors for electricity by region are developed from the losses. These standard, useful measures of the efficiency of electricity generation and T&D are multiplied by regional site electricity requirements for each sector of the economy in order to estimate primary electricity consumption. The conversion factor for primary natural gas used in this chapter is a less sophisticated, single multiplier, regardless of year or region. These primary estimates are added to the remaining direct fuel used to calculate total primary energy inputs for each sector of the economy. In this way, sector energy use is counted in terms of total primary inputs instead of just the energy content of site consumption. The adoption of new electricity-intensive technologies and fuel switching from fossil fuels to electricity nearly offset any efficiency improvements measured in terms of primary energy during 1985-1991.

Measuring Transformation and Distribution Losses

For consistency, all energy sources (natural gas, oil, district heat, and coal) should also be analyzed in a comprehensive way that includes all losses in primary energy estimates. Measuring energy intensity in the energy supply sector is essentially a comprehensive analysis of site energy consumption by all end-use sectors relative to the gross inputs for electricity generation and fossil fuel supply (primary energy consumption). The difference between primary and site energy consumption is the losses.

Primary Electricity Measures

The methodology for the conversion of site electricity consumption by region and end-use sector is described below and illustrated in the following tables:

- Utility net generation by fuel and region in kWh are converted to equivalent gross generation in kWh (including generator or shaft losses) by applying gross/net ratios commonly used by EIA for comparison with gross generation data from other countries.

- The resulting gross generation estimates, by region, are multiplied by the heat rates for each energy source to obtain gross inputs for electricity generation by utilities. Heats rates are available for fossil fueled, nuclear, and geothermal plants; the rates changed each year.

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[3] Losses occurring in the extraction and production phases for coal, petroleum, and natural gas are accounted for in mining, which pertains to the non-manufacturing industrial sector. Energy losses at refineries are also generally included in the industrial sector.

- Data on fuel sources used by nonutilities and net exporters to produce electricity purchased by US utilities is not available. Since this electricity is primarily produced from either fossil fuels or hydro resources, the heat rates of fossil-fueled steam generators are applied to the purchased energy.

- Transmission and distribution losses, estimated at 8 percent by the Department of Energy, Office of Energy Management,[4] are calculated for total gross generation, nonutility and net imported electricity. They are added to calculate gross inputs for electricity, by region.

Table A1. Example of Calculating Gross Inputs

Northeast 1991	Fossil Fuels	Nuclear	Hydro-power	Geo-thermal	Other	Nonutility Purchases	Net Imports
Net Generation (Billion kWh)	237.2	144.6	30.1	0	0.5	35.9	11.0
Gross/Net Ratio	1.07	1.06	1.01	1.06	1.07	1.07	1.07
Heat Rates (Btu/kWh)	10,305	10,740	*	20,997	*	*	*
T&D Losses	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Gross Inputs (Trillion Btu)	2,824	1,770	340	0	7	402	123

Notes: * Assume fossil fuel heat rate applied.
The equation is (Net Generation * Heat Rate) * (Gross/Net Ratio + T&D Losses)/1000
e.g., (237.2 * 10,352) * (1.07 + 0.08) / 1000 = 2,824

Source: EIA, *Measuring Energy Efficiency in the US Economy*, Draft Report prepared by Energetics, May 1995, Chapter 6, Appendix A Tables A1-A4.

- Electric sales data for each sector -- residential, commercial, industrial, and other[5] -- are developed for each region. In addition, utility plant use, which is calculated as the difference between gross and net generation, is added to the end-use totals. All regional estimates in kWh are multiplied by 3,412 Btu/kWh to yield Btu equivalents.

- Total gross energy inputs are divided by the total electricity consumption (both in Btu) for each region in order to obtain primary energy conversion factors.

Table A2. Example of Calculating Primary Electricity Conversion Factor

Northeast 1991	Residential	Commercial	Industrial	Other	Utility	Total
Electricity Sales (Billion kWh)	137.5	142.9	117.2	16.1	25.6	439.3
Electricity Sales (Trillion Btu)	469	488	400	55	87	1,499
Primary Conversion Factor						3.647

Notes: The equation for the primary conversion factor is Gross Inputs / Electricity Sales, both in Trillion Btu
e.g., 5,466/1,499 = 3.647

Source: EIA, *Measuring Energy Efficiency in the US Economy*, Draft Report prepared by Energetics, May 1995, Chapter 6, Appendix A, Tables A4-A5.

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[4] Office of Energy Management, *Transmission and Distribution Technologies, Multi-Year Program Plan, FY 1995-1999*, draft Sept. 16, 1994, p.4-12.

[5] Other sales include public street and highway lighting, railroads and railways, municipalities, divisions or agencies of state and federal governments under special contracts, and other utility departments.

- Primary electricity conversion factors are multiplied by the site electricity consumption for each end-use sector, by census region, to obtain the corresponding primary electricity estimates.

Calculating Primary Commercial Electricity Requirements
1991 Northeast Industrial Primary Electricity = 400 Trillion Btu * 3.647 = 1,459 Trillion Btu etc.

There are three main advantages to using the method described above:

- Generation, transmission and distribution losses are accounted for.
- Includes electricity consumption that was generated by both utilities and nonutilities.
- Since the heat rate used varies from year to year and by fuel source, changing efficiencies over time are captured.

Primary Natural Gas Measures

Natural gas supply measurements should include losses due to processing, pipeline transport, and distribution to consumers. EIA collects and publishes data on natural gas production, supply and consumption in the *Natural Gas Annual*. There is some confusion regarding at what point losses should be calculated. In electricity, the supply equation begins at generation, after all fuels have been extracted and transported to the power plant. A similar situation faces natural gas. Total dry natural gas production is less than gross withdrawals from wells because of the losses in volume due to the venting and flaring of the some of the gas, gas used for repressuring in order to effect greater ultimate recovery, removal of non-hydrocarbon gases, and extraction losses. This difference between gross withdrawals and total dry production is really a combination of transfers and removal of substances that should not be counted as natural gas supply.

The total supply of natural gas is the sum of total dry production, net imports, withdrawals from storage and a balancing term. The disposition of total supply includes consumption, deliveries at U.S. borders, and additions to storage. Losses are not assumed to explain the difference between natural gas supply and consumption. The range of losses for interstate gas pipeline distribution is about 0.5-1.5 percent while that of local distribution is about 2-3 percent. Since annual estimates of distribution losses are not available, they were assumed to be on average, approximately 2 percent.[6]

Losses on throughput natural gas (total amount of gas passing through the entire system) vary with the volume of gas and distance travelled in the pipeline. Any analysis of primary gas use should include a caveat about the uncertainty in the percentage losses on throughput energy, which were not estimated.

The primary conversion factor for natural gas is 1.02, constant across all end-use sectors and all years. This factor is multiplied by the site natural gas consumption estimates to calculate primary gas consumption for each end-use sector.

[6] Margo Natof of EIA guesstimate of losses due to distribution is about 2 percent, from a 10/21/94 conversation. Phil Runger at AGA claims the industry has been working on pipeline losses for years but still does not have an estimate of how much is actually lost.