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A COMPARATIVE ANALYSIS OF FUEL PRICE FORECASTS

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ABSTRACT

A comparative analysis of four sets of fuel price forecasts is made for each of the four primary energy sources: coal, oil, natural gas and uranium. These forecasts, together with historical data over the period from 1960 to 1977, are presented in graphical and tabular form to the year 2000. A graphical summary is then made of a synthesized forecast considered most likely for each fuel, plotted in common units of 1977 cents per million BTU, showing relative trends among competing energy forms.

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The MIT Regional Electricity Model developed by Paul L. Joskow, Associate Professor of Economics at MIT, and Martin L. Baughman, Associate Director of Energy Modeling at the Center for Energy Studies, University of Texas at Austin, is the principal means by which several electric energy policy scenarios have been analyzed by the LWR study group.*

This model, described in detail in the Joskow-Baughman article appearing in the Spring 1976 issue of the Bell Journal of Economics, is an engineering, econometric, and financial simulation of the U.S. electric utility industry. It includes submodels for energy supply and demand and for utility financing within specific regulatory structures and accounts for regional variations in these parameters.

The authors point out in their article that the future character of the U.S. electric utility industry is quite sensitive not only to the obvious leverage of the varying regulatory environment, but also to the costs of the major competing fuels: coal, uranium, and oil. The model is constrained from building any new plants which use natural gas, but the price of natural gas does have strong effects in some regions on the price of electricity produced by existing plants and, thereby, on total demand in those regions.

In view of this sensitivity and the fact that some time has elapsed since fuel price assumptions for the model were made originally, a review of the energy price inputs has been undertaken. Of specific interest are

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*The LWR study group, organized under the auspices of the MIT Energy Laboratory and the Department of Nuclear Engineering, was sponsored by the U.S. Department of Energy.

the projections for future prices of coal, oil, natural gas, and uranium (U_3O_8) over the period between 1977 and the year 2000. In this paper "fuel price" will be expressed in terms of an "average national price of fuel delivered" to the utilities; it will be in 1977 constant dollars and will normally appear in the form of "cents per million Btu" as a common unit of measure. Comparisons have been made of four sets of fuel price projections: (1) the Baughman-Joskow set of price assumptions as outlined in the 1976 article in the Bell Journal of Economics, (2) the current price assumptions of the model as used in the December 1977 base case simulations, (3) the August 1977 industrial energy price projections of the U.S. Department of Energy's Office of Energy Information and Analysis, and (4) the May 1976 price projections of the Institute for Energy Analysis of the Oak Ridge Associated Universities as revealed in a recently released publication entitled "Economic and Environmental Implications of a U.S. Nuclear Moratorium, 1985-2010." As a matter of historical perspective, comparable data have been presented in 1977 constant dollars for the period from 1960 to 1976 from the Edison Electric Institute (EEI) Statistical Yearbooks.

Because each set of price assumptions is expressed in different forms, some translational errors may appear in the final analysis. For example, the historical data from the Edison Electric Institute are expressed in current year dollars, per million Btu delivered to the utility. For natural gas in 1976 this figure is 102.4 cents. The figures for natural gas from the Institue for Energy Analysis are expressed in 1975 dollars at the wellhead -- $0.43/mcf (presumably this

price is only for gas not previously fixed by contract). The Baughman-Joskow natural gas prices are for "intrastate" commerce as expressed in future dollars, presumed to inflate at 5.5% per annum. The base case simulation presents its natural gas prices in terms of 1977 constant dollars (national average) per million Btu. Lastly, the U.S. Department of Energy (DOE) projects its natural gas prices in terms of industrial price increases per year, for example, the price of natural gas as paid by industrial users is projected by DOE to increase in real terms by 8.5% per annum from 1975 to 1985, but DOE provides no estimates for years after that. The errors in translating these figures to a common base, it is hoped, have been minimized by analyzing in detail the differences in these price schemes from actual price data for the recent years of 1974, 1975, and 1976, where overlapping occurs.

Data for the year 1977 have been constructed by taking recent data as published in the U.S. Department of Energy's "Monthly Energy Review" and correlating such items as "world price of oil" and "refiner's acquisition cost per barrel," to recent years of EEI data and then making a projection. This analysis reveals, for example, that the mark-up from average refiner's acquisition cost (after the government's entitlements) to the delivered price of residual fuel oil is approximately 9%.

Coal

Figure 1 presents the comparative results for the delivered price of coal. As can be seen from the graph, the real price of coal had been slowly but steadily declining from 1960 to a low in 1969. It gradually

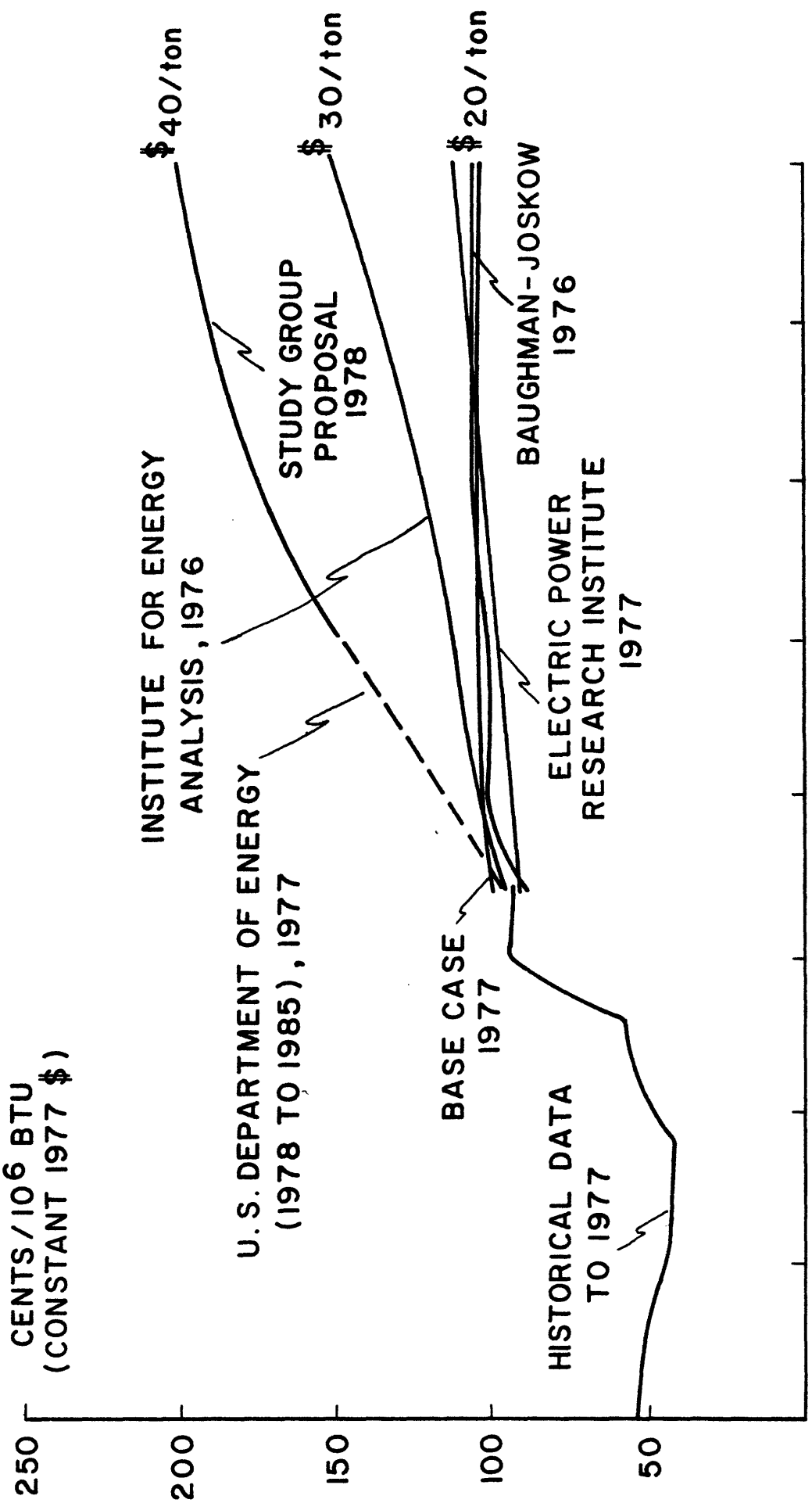

FIGURE 1: COST OF COAL TO UTILITIES

increased between 1970 and 1973, but was in this latter year essentially the same price it had been in 1960 -- slightly under 60 cents per million Btu (in 1977 constant dollars). From 1969 to 1974 oil prices had quadrupled in real terms and coal finally followed in this pattern by doubling in price from 44 cents per million Btu in 1969 to 83 cents in 1974. In real terms, coal prices (as with oil) reached a peak in 1975, followed by two years of slight decline. The ratio of coal price to oil price held constant at 3:4 in the sixties and is now about 1:2.

The Institute for Energy Analysis (Oak Ridge Associated Universities) argues that coal reserves are abundant and accessible in the U.S. and that considerable competition exists in the industry; accordingly, it is argued, coal prices should not continue to follow oil directly, but will be determined, instead, more by the cost of coal production alone. This cost, they figured in 1976, could rise at most about 2% per year in real terms. The study cited an identical figure as being the most recent data from the U.S. Department of Energy. The Baughman-Joskow article, also in 1976, and the December 1977 base case simulations, show coal prices to be completely independent of oil prices, and shows them to be constant in real terms over the next 25 years at about 100 cents per million Btu (approximatly $20/ton delivered). In contrast to these estimates, the more recent information from the Office of Energy Information and Analysis of the U.S. Department of Energy , shows a continuous upward price movement of 5.66% per year through 1985. In the absence of any other data, this price curve was then arbitrarily projected asymptotic to the 2% growth curve of the Oak Ridge group, resulting in an AD 2000 price projection of approximately $40/ton in 1977 dollars.

The recent reevaluation by DOE may have been brought on by a generally acknowledged feeling among those studying coal that doubling coal production may not be as easy as once thought, and in recognition that there are a great number of uncertainties about costs of coal use and of resolving potential environmental impacts (water for coal slurry pipelines, desulfurization). In view of these thoughts, special types of coals ("conforming coals") may be required for general utility use and the higher average price for coal in the next decade may be the more reasonable projection.

Oil

Like coal and natural gas, oil prices declined in real terms over the period from 1960 to 1969, bottoming out in 1969 at 55.5 cents per million Btu ($3.46/bbl) in 1977 dollars. In 1967, U.S. proven reserves peaked and began a rather steep decline, which has continued at a constant rate since that year with the one exception of the Alaskan North Slope finds. This rate of depletion (net) is about -3.3% per annum, ignoring the Alaskan find. Oil production in 1969 peaked and has been declining since.

Concurrent with these developments, U.S. reliance upon foreign oil imports, along with other oil-deficient industrial nations, increased to a point where the oil cartel of exporting countries became viable. Oil price increased gradually in the period of transition from 55.5 cents/10^6 Btu (delivered to utilities) in 1969 to 105.8 cents in 1973.

In 1974, the OPEC cartel began to exert its full strength, quadrupling the price of oil on the world market to more than $12/bbl. The price of oil delivered to the U.S. electric utilities increased accordingly, but to a level below world price, because oil pricing regulations imposed upon domestic production (old oil was frozen at $5.25 per barrel) lowered the average prices. Oil price peaked in 1975 at 223.7 cents/10^6Btu ($13.66/bbl in 1977 dollars), and declined in real terms in the years following to a current 1977 price of 210.7 cents/10^6Btu ($12.95/bbl). The average cost of an imported barrel,* as a comparison in mid-1977, was $14.61/bbl; a domestic barrel was $9.15 (the average of "old oil," "new oil" and "produced under exempted conditions"); and the average refiner's acquiition cost (after entitlements) was $11.80/bbl.** It is interesting to note at this point that the cost of residual fuel oil to the utilities is about 9 to 10 percent above the average refiner's acquisition cost. This latter cost can be expected to rise eventually to the cost of an imported barrel, given that "new domestic oil" is priced comparably with imports and that "old domestic oil" is fast being depleted, thereby reducing its fraction in the domestic price computation. Therefore, in the next decade, oil prices as paid by U.S. utilities can be expected to rise gradually to, and ultimately follow, world price.

World price of oil, now established by dictum of OPEC, is expected to rise more rapidly than general prices for two main reasons: (1) world

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*"Landed cost" on U.S. shores.

**FEA's Monthly Energy Review, August 1977, p. 71.

demand for oil will increase in response to population growth, industrialization of less developed countries, and in general, with world GNP growth, and (2) more costly oil resources will be developed, effectively placing a floor under world prices equivalent to replacement cost.

Assuming restraint on the part of OPEC, as exhibited in recent price announcements, to limit price increases to the rate of world inflation, the price of oil on the world market is expected to increase in real terms to U.S. refiners by not more than 2 to 3 percent per year.

The Department of Energy projects domestic oil prices to rise about 2.55% per annum to 1985. The Oak Ridge study group projects that domestic oil prices will rise to world price by or prior to 1985, and will rise thereafter by 3% per annum; world price in 1985 (assumed to mean landed cost of world oil on U.S. shores) was assumed to be $16/bbl in 1975 dollars ($17.86 in 1977 dollars). The Baughman-Joskow simulation assumed prices would increase rapidly between 1975 and 1980, but would level off indefinitely after 1985 at about 255 cents/10^6 Btu ($14.79/bbl) delivered to the utilities; using the 9% rule for refiner's mark-up, this would put landed world oil at less than $13.60/bbl. The current base case oil prices start in 1977 at 296 cents/10^6 Btu, which is 40% above actual price data, seems to be in error. A graphical summary of these projections appears in Figure 2.

Natural Gas

The price of interstate U.S. natural gas, whether produced domestically or imported as LNG, is controlled by the Federal Energy

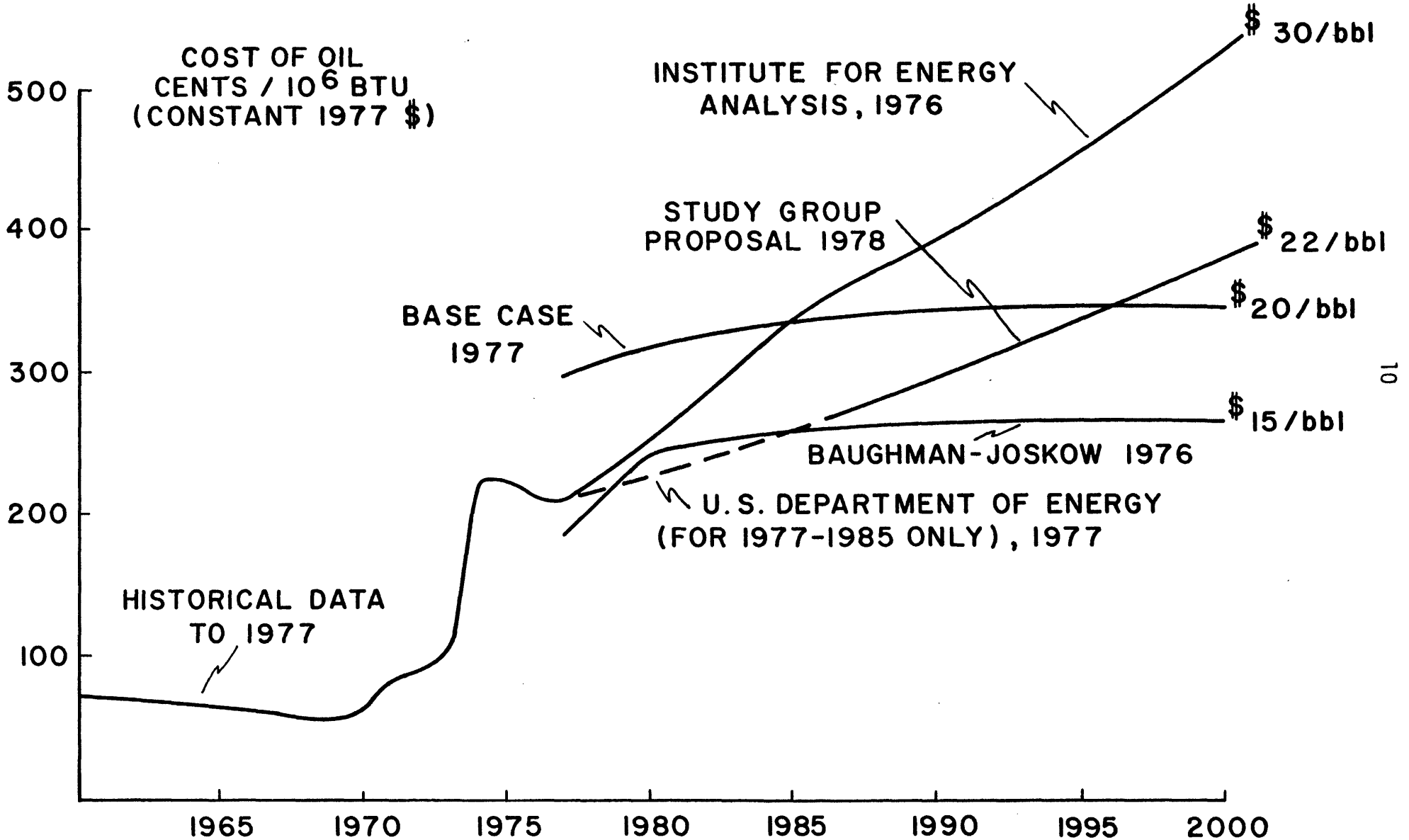

FIGURE 2: COST OF OIL TO UTILITIES

Regulatory Commission (FERC, the old FPC), now part of the Department of Energy, until such time that natural gas may be deregulated. In the precedent setting Supreme Court ruling of 1954, this price by law must be reflective only of the costs of production and not of market value with respect to other fuels. Consequently, the historical pattern of natural gas prices has been rather constant after adjustments for inflation. Despite its attractiveness as a premium fuel, exceptionally clean and versatile, its price through 1975 was below that of equivalent amounts of oil, and even coal.

Intrastate gas, however, is an uncontrolled commodity, and many utilities which have gas-fired plants, built these plants in gas-producing states. Market prices in the intrastate market, and recent pricing decisions of the FERC, have together pushed the average national delivered price of natural gas to 130 cents/10^6 Btu, as compiled by EEI.

Forecasts are extremely uncertain for this fuel. Recent intrastate prices have risen to the order of $2.25/mcf, but may be falling off somewhat now; new gas at the wellhead destined for interstate pipelines is $1.48; LNG landed at east coast shores from Algeria has been running at $1.23 to $1.30/mcf under old contracts and new contracts may be much higher; President Carter's energy plan calls for a new price at the wellhead of $1.75, and adds a phased-in system of "use taxes" on utilities, tied to the price of oil as an incentive to convert to coal, equaling 50 cents per 10^6 Btu; lastly a plurality of U.S. Senators has voted for deregulation where the natural gas price could seek its own level in the marketplace -- probably above that of oil because of its premium fuel attributes.

Because of these uncertainties, DOE stopped forecasting any price as of August 1977. The last estimate had natural gas prices rising rapidly and reaching the equivalent price of oil on the world market by 1985. The Oak Ridge study group also projects natural gas prices to equal that of world oil by 1985. In stark contrast, both the Baughman-Joskow simulation, and that of the December 1977 base case simulations, show natural gas prices slightly declining through 1985, and then remaining relatively constant through the year 2000. This latter scenario presumably expects abundant new discoveries in the presence of strong financial incentives, thereby driving price down somewhat. A summary of these four projections appears in Figure 3.

Uranium

Like natural gas, uranium prices are extremely uncertain given wide variations in potential supply and demand. Common wisdom among utility planners, however, says that U_{3O8} prices will rise in real terms only by 1 or 2 percent per year from the current spot price of $42 to $44 per pound. A recently published report* surveying the 1976 uranium marketing activity in the U.S. cited average delivered prices for contracts each year out to 1985. In current dollars, these delivery prices seem to average about $17/lb in 1976 and $30/lb in 1985, assuming 5.5% inflation annually over this period, the price rise in real terms equals 1.57% per year. Recent interviews with the Public Utility Service of New Hampshire

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*Supply Evaluation Branch, Division of Uranium Resources, ERDA, 8/77 as cited in Nuclear News, August 1977, p. 67.

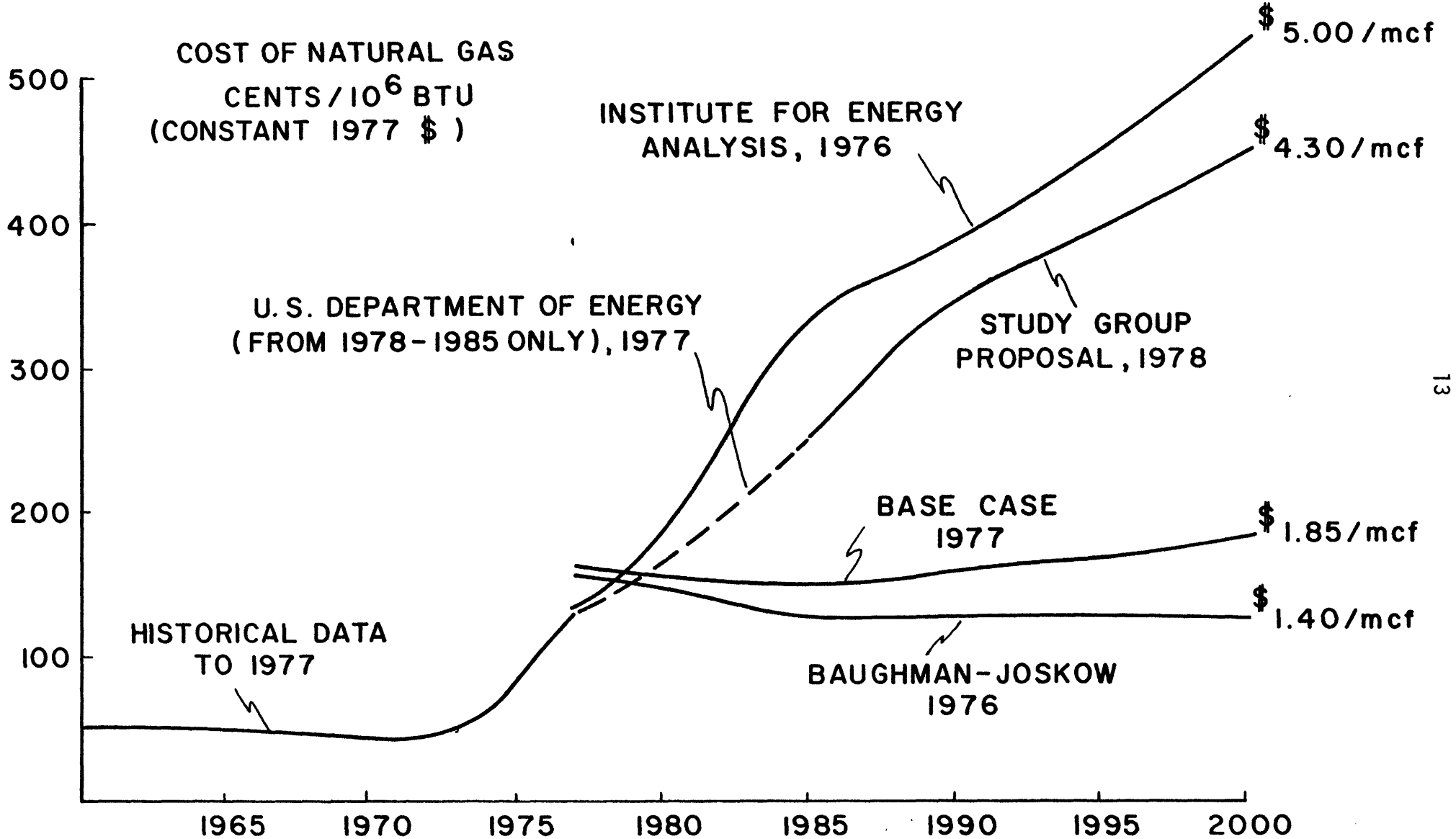

FIGURE 3: COST OF NATURAL GAS TO UTILITIES

(a participant in the construction of Seabrook #1 and #2) revealed that they are currently negotiating for U_3O_8 at or slightly below the spot price of $42/lb, indicating that uranium not already under contract may be much more expensive than these "averaged" contract prices.

Given these limited glimpses of the uranium market, a future price scheme has been constructed as follows: (1) uranium now under contract as of the end of 1976 (cited in the abovementioned survey) will increase in real terms at 1.5% per annum from the 1976 price of $16.10/lb ($17.00/lb in 1977 $) due to renegotiations; (2) uranium not under contract as of this date is assumed to also increase in real terms at 1.5% per annum, but from the 1977 spot price of $42/lb; (3) the average national price in any one year is the weighted sum of these two portions of total supply based upon data showing the percent of uranium requirements (as projected by DOE) committed to the lower prices by prior contract. A graphical representation of this averaging scheme is portrayed in Figure 4.

Besides the "$42 ceiling," the "$17 floor" and the weighted average price curve, Figure 4 shows the U_3O_8 price assumptions made in 1976 by Baughman and Joskow (converted to 1977 constant dollars) and the price assumption of the December 1977 base case simulations. The base case assumption appears very low because it reflects a "price-versus-cumulative-production" curve based on ERDA's 1976 "forward cost" figures. These figures listed more than 700,000 tons of U_3O_8 available at $10/lb and below, and the model, over the course of 20 future years, predicted cumulative consumption to be not much more than this.

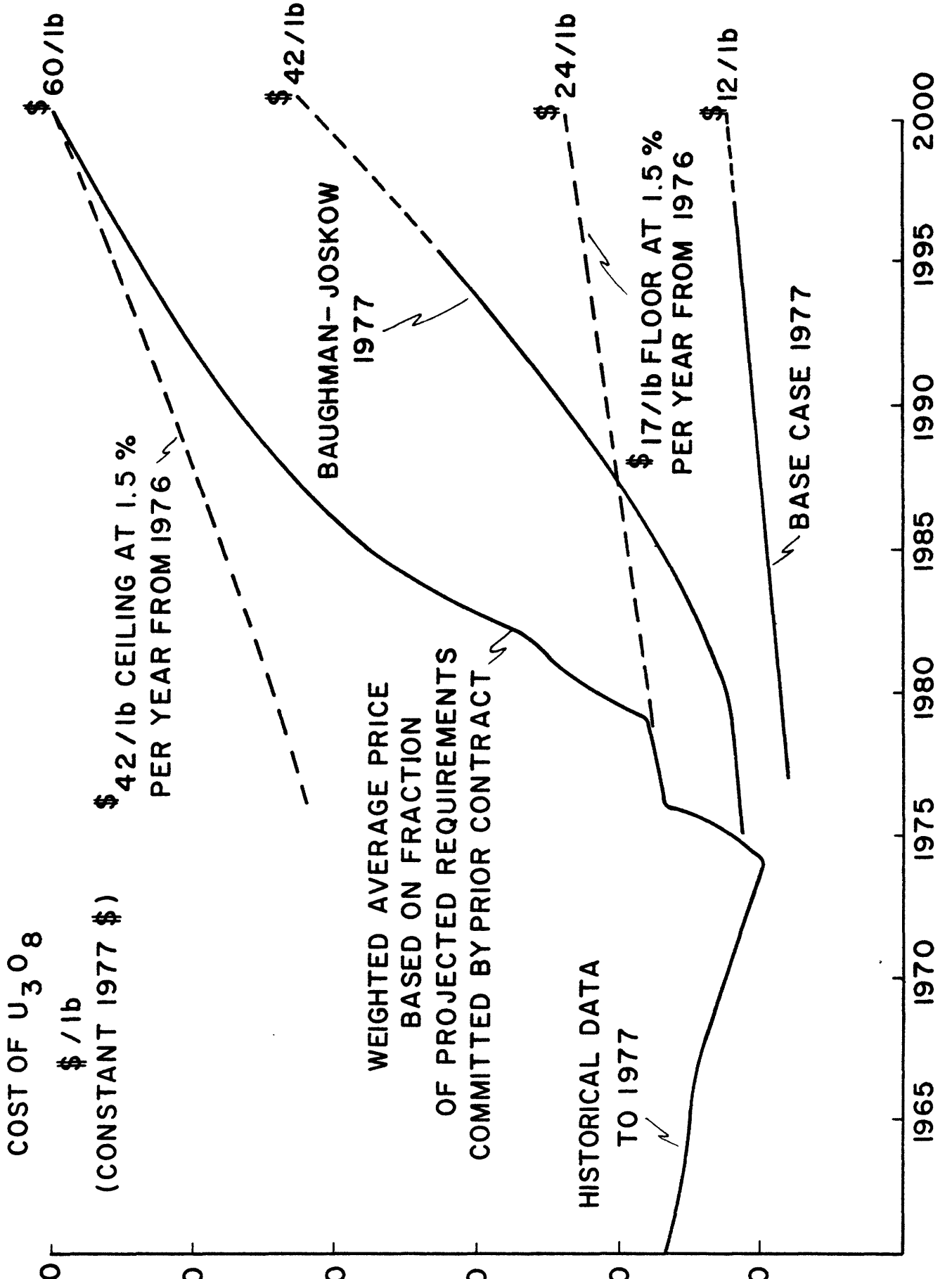

FIGURE 4: COST OF U_3O_8 TO UTILITIES

Hence, the price figure used is that of the forward cost, and is unrealistic.

Because previous figures (on oil, gas and coal) have been expressed in the comparative value of "cents per 10^6 Btu," an atttempt is made below to show what the "price per pound" figures might mean if converted to the common unit of prices measure of the other fuels. To do this, the following and somewhat arbitrary assumptions have been made:

a) nuclear reactor life = 30 years

b) 1000 MWe at 30% efficiency

c) utilization factor = 0.636

d) initial core load = 530 short tons U_3O_8

e) annnual makeup = 230 short tons U_3O_8 (burnup = 27,000 MWd/tonne)

f) total 30-year U_3O_8 requirement = 7200 short tons.

Given these assumptions, the thermal output of U_3O_8 as a fuel is 132 x 10^6 Btu/lb. At the cost ranges displayed on Figure 4, this conversion factor yields the following:

a) for \$17/lb U_3O_8 -- 13 cents/10^6Btu

b) for \$42/lb U_3O_8 -- 32 cents/10^6Btu

Clearly, U_3O_8, even at the higher price of \$42/lb, is relatively low-priced fuel when compared to the conventional forms of energy. It is noted, however, that costs of enrichment and fuel fabrication are not included in these comparisons.

Summary

In summary, economic considerations drive the MIT Regional Electricity Model and, by the authors' (Baughman and Joskow) own evaluation, the model is very sensitive to fuel price inputs. To provide meaningful analysis, fundamental assumptions about prices must be credible. Current assumptions in the December 1977 base case simulation are at significant variance from price projections made by DOE, the Oak Ridge study group and, in some instances, actual contract prices. From Figures 1 through 4 one curve for each fuel has been constructed as a suggested alternative to the December 1977 price assumptions; these four curves are summarized in Figure 5. Tables 1 through 8 present supporting data and computations used to construct the curves on Figures 1 through 5.

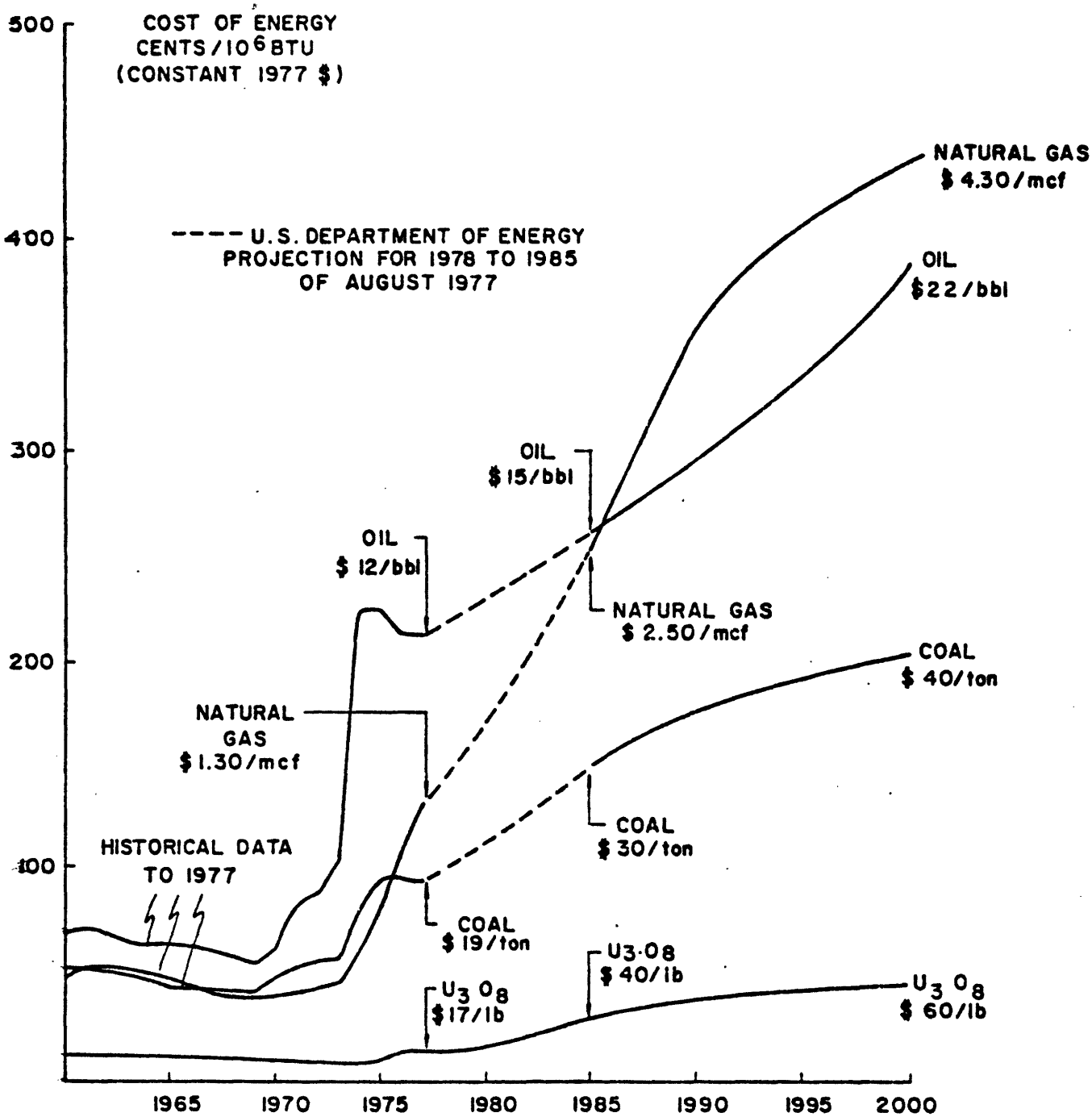

FIGURE 5: SUMMARY OF HISTORICAL (TO 1977) AND PROJECTED ENERGY COST TO U.S. UTILITIES

TABLE 1: SUMMARY TABLE OF PROJECTED ENERGY PRICES (CENTS/10^6 Btu)
(1977 CONSTANT $)

FUEL	YEAR	BJ 1976	DECEMBER 1977 BASE CASE	IEA/ORAU 1976	EEI/ DOE/MIT
COAL	1975	81	-	-	96.4
	1977	89	100	96	96
	1980	102	103	102	113
	1985	101	101	112	149
	1990	105	104	137	189
	2000	(105)	(101)	151	200
OIL	1975	157	-	-	223.7
	1977	186	296	211	211
	1980	241	318	251	227
	1985	255	335	336	260
	1990	261	340	389	292
	1995	258	341	451	332
	2000	(260)	(340)	(523)	376
NATURAL	1975	165	-	-	83.7
GAS	1977	157	163	180	130
	1980	146	159	186	166
	1985	130	153	336	250
	1990	130	169	389	350
	1995	130	169	451	400
	2000	(130)	(175)	(523)	450

BJ-76: Baughman-Joskow Bell Journal article, Spring 1976.
December 1977 Base Case: MIT Regional Electricity Model, run on 12/21/77.
IEA/ORAU '76: Institute for Energy Analysis, Oak Ridge Associated Universities, May 1976.
EEI/DOE/MIT: Edison Electric Institute to 1976, MIT estimate for 1977 using recent DOE data, DOE projections from 77 to 85, and then MIT estimates 85-2000.

TABLE 2: HISTORICAL COAL PRICES TO UTILITIES 1960-1976
NATIONAL AVERAGE DELIVERED COST IN CENTS
PER 10^6 Btu (1977 CONSTANT DOLLARS)

YEAR	COAL Btu/lb	AVG. COST $/TON	AVG. COST ¢/10^6Btu	CPI FACTOR	AVG. COST 1977 $/TON	AVG. COST 1977 ¢/10^6Btu
77	10,870	20.81	95.7	1.0000	20.81	95.7
76	10,870	19.29	88.7	1.0551	20.35	93.6
75	10,828	18.71	86.4	1.1161	20.88	96.4
74	10,925	14.81	67.8	1.2180	18.04	82.6
73	11,130	9.32	41.9	1.3516	12.60	56.6
72	11,321	8.69	36.3	1.4358	12.48	55.1
71	11,265	8.18	36.3	1.4831	12.13	53.8
70	11,358	7.08	31.2	1.5469	10.95	48.3
69	11,726	6.26	26.7	1.6384	10.26	43.7
68	11,821	6.05	25.6	1.7265	10.45	44.2
67	11,825	5.97	25.2	1.7990	10.74	45.3
66	11,886	5.86	24.6	1.8508	10.85	45.5
65	11,942	5.83	24.4	1.9037	11.10	46.5
64	11,991	5.88	24.5	1.9365	11.39	47.4
63	12,005	6.01	25.0	1.9618	11.79	49.0
62	12,025	6.15	65.6	1.9857	12.21	50.8
61	12,024	6.22	25.9	2.0078	12.49	52.0
60	12,041	6.26	26.0	2.0282	12.70	52.7

Source: Edison Electric Institute Statistical Yearbooks. Figures for 1977 are estimates based upon data from the FEA Monthly Energy Review, adjusted to EEI format.

TABLE 3: HISTORICAL OIL PRICES TO UTILITIES 1960-1976

NATIONAL AVERAGE DELIVERED COST IN CENTS

PER 10^6 Btu (1977 CONSTANT DOLLARS)

YEAR	RESIDUAL FUEL OIL Btu/GAL	AVG. COST $/BBL	AVG. COST ¢/10^6Btu	CPI FACTOR	AVG. COST 1977 $/BBL	AVG. COST 1977 ¢/10^6Btu
77	146,350	12.95	210.7	1.0000	12.95	210.7
76	146,350	12.34	200.7	1.0551	13.02	211.8
75	145,421	12.24	200.4	1.1161	13.66	223.7
74	145,719	11.21	183.2	1.2180	13.65	223.1
73	145,225	4.77	78.3	1.3516	6.45	105.8
72	144,933	3.78	62.1	1.4358	5.43	89.2
71	146,489	3.41	55.5	1.4831	5.06	82.3
70	146,663	2.43	39.8	1.5469	3.79	61.6
69	148,241	2.11	33.9	1.6384	3.46	55.5
68	148,692	2.13	34.1	1.7265	3.68	58.9
67	149,689	2.07	33.0	1.7990	3.72	59.4
66	150,234	2.08	32.9	1.8508	3.85	60.9
65	150,311	2.10	33.3	1.9037	4.00	63.4
64	150,723	2.08	32.9	1.9365	4.03	63.7
63	150,671	2.12	33.6	1.9618	4.16	65.7
62	150,764	2.18	34.5	1.9857	4.33	68.5
61	150,558	2.23	35.2	2.0078	4.48	70.7
60	150,514	2.17	34.3	2.0282	4.40	69.6

Source: Edison Electric Institute Statistical Yearbooks. Figures for 1977 are estimates based upon data from the FEA Monthly Energy Review, adjusted to EEI format.

TABLE 4: HISTORICAL NATURAL GAS PRICES TO UTILITIES 1960-1976

NATIONAL AVERAGE DELIVERED COST IN CENTS

PER 10^6 Btu (1977 CONSTANT DOLLARS)

YEAR	NATURAL GAS Btu/CU.FT.	AVG. COST $/BBL	AVG. COST ¢/10^6 Btu	CPI FACTOR	AVG. COST 1977 $/BBL	AVG. COST 1977 ¢/10^6Btu
77	1023	133.0	130.0	1.0000	133.0	130.0
76	1023	104.8	102.4	1.0551	110.6	108.0
75	1026	77.0	75.0	1.1161	85.9	83.7
74	1022	51.2	50.1	1.2180	62.4	61.0
73	1024	36.0	35.2	1.3516	48.7	47.6
72	1027	31.9	31.1	1.4358	45.8	44.7
71	1025	29.9	29.1	1.4831	44.3	43.2
70	1029	28.0	27.2	1.5469	43.3	42.1
69	1031	26.4	25.6	1.6384	43.3	41.9
68	1037	26.1	25.1	1.7265	45.7	44.3
67	1034	25.4	24.6	1.7990	45.1	43.3
66	1036	25.8	25.0	1.8508	47.8	46.3
65	1033	25.7	24.9	1.9037	48.9	47.4
64	1031	26.1	25.3	1.9365	50.5	49.0
63	1027	26.1	25.4	1.9618	51.2	49.8
62	1034	27.2	26.3	1.9857	54.0	52.2
61	1028	27.0	26.3	2.0078	54.2	52.8
60	1034	25.2	24.4	2.0282	54.2	52.8

Source: Edison Electric Institute Statistical Yearbooks. Figures for 1977 are estimates based upon data from FEA's Monthly Energy Review and adjusted to EEI format.

TABLE 5: PROJECTED FUEL PRICES TO UTILITIES, 1977-2000
FROM U.S. DEPT. OF ENERGY (DOE) AND MIT REGIONAL
ELECTRICITY MODEL DECEMBER 1977 BASE CASE
CENTS PER MILLION Btu (1977 CONSTANT DOLLARS)

	COAL		OIL		NATURAL GAS	
YEAR	DOE	DEC 1977 BASE CASE	DOE	DEC 1977 BASE CASE	DOE	DEC 1977 BASE CASE
1977	96.7	99.7	210.7	295.8	130.0	163.1
78	101.1	101.0	216.1	302.8	141.1	161.7
79	106.8	102.0	221.6	310.8	153.0	160.3
80	112.9	102.6	227.2	318.3	166.0	158.8
81	119.3	103.0	233.0	321.3	180.2	157.1
82	126.0	103.2	239.0	325.3	195.5	155.5
83	133.2	103.1	245.1	327.1	212.1	153.8
84	140.7	102.8	251.3	329.7	230.1	152.0
85	148.7	101.0	257.7	334.6	249.7	153.2
86	154	101.7	264.3	335.3	270	155.3
87	160	102.0	271.0	336.4	290	157.0
88	164	103.2	277.9	336.8	310	158.9
89	168	104.0	285.0	338.6	330	160.3
90	173	104.6	292.3	340.1	350	161.7
91	177	104.8	299.8	340.4	360	163.1
92	180	104.8	307.4	340.7	370	164.6
93	183	104.6	315.2	341.0	380	166.2
94	183	104.2	323.3	341.2	390	167.6
95	189	103.7	331.5	341.4	400	169.4
96	192	102.9	340.0	341.5	410	170.1
97	194	102.0	348.6	341.1	420	172.0
98	196	102.0	357.5	341	430	173.0
99	198	102.0	366.6	341	440	174.0
00	200	102.0	376.0	341	450	175.0

Sources: DOE: U.S. Department of Energy August 1977 fuel price forecasts through 1985: Coal -- 5.66% per annum, oil -- 2.55% per annum, gas -- 8.50% per annum.
BASE CASE: simulation of 12/21/77.

Table 6

	COAL			OIL			NATURAL GAS			U_3O_8	
	$/Ton	$/Ton	¢/10^6BTU	$/bbl	$/bbl	¢/10^6BTU	¢/MCF	¢/MCF	¢/10^6BTU	$/lb	$/lb
Year	Current	1977$	1977$	Current	1977$	1977$	Current	1977$	1977$	Current	1977$
1975	14.50	16.18	81	8.18	9.13	157	155	173	165	9.56	10.64
1980	24.00	20.44	102	16.44	14.00	241	180	153	146	14.54	12.38
1985	31.00	20.20	101	22.69	14.78	255	210	137	130	27.33	17.81
1990	42.50	21.19	106	30.30	15.11	261	274	137	130	47.12	23.49
1995	55.00	20.98	105	39.25	14.97	258	360	137	130	80.94	32.20
2000	-----	-----	(105)	-----	-----	(260)	---	---	(130)	-----	(44.00)
		5.5%			5.5%			5.5%			
		per annum			per annum			per annum			
1977	-----	-----	89	-----	-----	186	---	---	157	-----	11.30

Assumptions used in the 1976 Bell Journal presentation of the Baughman-Joskow Regional Electricity Model (MIT).

Source: Joskow, P.L. and Baughman, M.L. as presented in their discussion in the Spring 1976 Bell Journal of Economics.

TABLE 7: INSTITUTE FOR ENERGY ANALYSIS
OAK RIDGE ASSOCIATED UNIVERSITIES
CENTS PER MILLION Btu 1977 CONSTANT DOLLARS

YEAR	COAL ¢/10^6BTU	OIL ¢/10^6BTU	NAT. GAS ¢/10^6BTU
1977	95.7	210.7	130.0
78	97.6	223.3	146.4
79	99.6	236.7	164.8
80	101.6	250.9	185.5
81	103.6	265.9	208.9
82	105.7	281.8	235.2
83	107.8	298.7	264.8
84	109.9	316.6	298.1
85	112.1	335.6	335.6
86	114.4	345.7	345.7
87	116.7	356.0	356.0
88	119.0	366.7	366.7
89	121.4	377.7	377.7
90	123.8	389.1	389.1
91	126.3	400.7	400.7
92	128.8	412.7	412.7
93	131.4	425.1	425.1
94	134.0	437.9	437.9
95	136.7	451.0	451.0
96	139.4	464.5	464.5
97	142.2	478.5	478.5
98	145.0	492.8	492.8
99	148.0	507.6	507.6
00	151.0	522.9	522.9

Source: "Economic and Environmental Impediments of a U.S. Nuclear Moratorium, 1985-2010," IEA/ORAU, May 1976.

COAL: Assumed to rise in real price at 2% per annum.

OIL: Even annual rise in real price from 1977 to 1985 of 6% per annum to a 1985 price of 17.86 per barrel ($16/bbl in 1975 dollars), adjusted from refiners' acquisition price to residual fuel oil by a factor of 1.09; beyond 1985, 3% per annum.

NATURAL GAS: Even annual rise in real price to match oil by 1985.

Table 8: COMPUTATION SCHEDULE FOR FORECASTED U_3O_8 PRICES IN DOLLARS PER POUND AND CENTS PER MILLION BTU (1977 CONSTANT DOLLARS)

Year	$U_3O_8^*$ Required (10^3Tons)	$U_3O_8^*$ Contracted (10^3Tons)	Fraction Contracted (%)	Fraction Not Contracted (%)	Average Contracted Price ($/lb)	Average New Contract ($/lb)	Average Price ($/lb)	Cents Per 10^6 BTU Equivalent
1975	12	--	100	0	12.00	--	12.00	9
1976	12	--	100	0	17.00	--	17.00	13
1977	13	--	100	0	18.40	41.60	18.40	14
1978	20	--	100	0	20.00	42.30	20.00	15
1979	26	22	85	15	22.10	43.00	25.20	19
1980	31	24	77	23	23.60	43.60	28.20	21
1981	33	23	70	30	25.20	44.20	30.90	23
1982	37	23	62	38	26.80	44.90	33.70	26
1983	35	19	54	46	26.30	45.50	33.10	27
1984	42	17	40	60	25,20	46.30	27.90	29
1985	41	15	37	63	29.50	47.00	40.50	31
1986	42	12	29	71	31.40	47.70	43.00	33
1987	45	9	20	80	33.40	48.30	45.30	34
1988	44	8	18	82	35.40	49.10	46.60	35
1989	45	8	18	82	37.70	49.90	47.70	36
1990	45	7	16	84	40.10	50.60	48.90	37
1991	--	--	--	--	--	51.30	49.90	38
1992	--	--	--	--	--	52.00	50.90	39
1993	--	--	--	--	--	52.90	51.90	39
1994	--	--	--	--	--	53.70	52.90	40
1995	--	--	--	--	--	54.50	54.00	41
1996	--	--	--	--	--	55.40	55.20	42
1997	--	--	--	--	--	56.40	56.40	43
1998	--	--	--	--	--	57.60	57.60	44
1999	--	--	--	--	--	58.80	58.80	45
2000	--	--	--	--	--	60.00	60.00	46

*U_3O_8 requirements and amounts under contract were obtained from Nuclear News, August 1977, p. 67 in a summary of a report from Supply Evaluation Branch, Division of Uranium Resources, ERDA, August 1977.