ALTERNATIVE ASSUMPTIONS ABOUT LIFE STYLE, POPULATION, AND INCOME GROWTH: IMPLICATIONS FOR POWER GENERATION AND ENVIRONMENTAL QUALITY

by

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Preface

In the following pages we will discuss issues which affect the health, income, and beliefs of many in our audience. We would like to state that we are seeking no villains or scapegoats. It is true that, as Pogo observed, "We have met the enemy and he is us," but it is equally true that our present circumstances are a logical consequence of our political and economic institutions. We are not seeking to show that investor-owned utilities are less conscientious than public entities such as the Tennessee Valley Authority or the Bureau of Reclamation, or the reverse. We do not believe that electric utilities have been inefficient in supplying electricity. We shall attempt to examine some of the implications of alternatives in life style, population and income growth, and public policy for electricity generation and environmental quality.

Level I: The Family as Policy Maker

In the past year Barry Commoner, Michael Corr, and Paul J. Stamler have been developing information showing the environmental implications of our choices between the various commodities available to us.[1] Much of this information is related to electricity use. From their work (and other sources[2]) we can construct the beginnings of an energy budget for two representative families of four with equivalent material standards of living.

The Allen family lives in a wood frame house with three bedrooms on the edge of a small town. Their lot is surrounded by deciduous trees, and therefore, is shaded in the summer and open to the sun in the winter. The Brown family lives in a mobile home, as do one third of all families moving into new single-family homes. It is air conditioned. Consequences: Lumber and metal are both formed by energy. An important difference is that the molecular construction of wood is formed through photosynthesis by solar energy, and aluminum is smelted from bauxite using electricity or other energy sources. By weight, Family B's aluminum may use 150 times as much fuel energy as lumber. Their air conditioning uses 3,000-4,000 KWH's per year. Family A's air conditioning also depends on energy, but it is solar energy (to grow the leaves each spring) and wind.

Family B has electric heat (10,000-15,000 KWH per year) which is generated from fuel oil. Family A burns fuel oil in their home. Since B's utility can buy large quantities of low grade oil and burn it efficiently (about 1/3 conversion to electricity), their cost per delivered heat unit is about the same as Family A, although fewer gallons are used by A. The air pollution caused by the A's is about the same as the pollution from burning the oil in the power plant for the B's. Neither family is able to obtain natural gas, and coal is more expensive and "dirtier" for home heating in their area. There doesn't seem to be important energy options in home heating.

The Allens are within walking distance of work, schools, and stores, and have one car. The Browns home is 5 miles from all three; they use two cars daily and their children ride a school bus. The Allens average about 20,000 miles a year in their car, and the Browns use each of their's for 15,000 miles a year. With a car lasting about 100,000 miles, the Browns consume .3 of a car a year and 2,000 gallons of gasoline; the Allens use .2 of a car a year and 1,333 gallons of gasoline. Counting electricity used in both automobile manufacturing and repairing and gasoline refining, the Browns use 3000 KWH/year enbodied in their automobile transportation, 1,000 more than the Allens.[3/]

The Allens wear cotton and woolen clothing, and the Browns wear nylon and rayon in half of their clothing. Nylon is made from petroleum and natural gas, and uses fuel energy and electricity in its manufacturing. Cotton and wool obviously use energy also, but a substantial portion is photosynthetic.

The thrust of these comparisons is clear. The Allens and Browns have similar living standards, but the Browns use 1.5 to 4 times as much electricity and total energy per year. And we can speculate with some confidence that the environmental stress of manufacturing and disposing of the commodities which are part of the Brown's life style is greater than for the Allens.

What are some of the implications of this beginning of alternative energy budgets? Which family is more representative? I believe the Browns are. (The authors, for example, live 25 miles and 5 miles from work; and I prefer nylon to wool.) Are the Browns irresponsible in their preferences? I think not. With existing prices and knowledge, their preferences are not illogical. What impact on electricity use would a single Brown have if he followed the Allen's preferences? Less than 1/400 millionth. Will the potential impact of preferring less electric intensive commodities increase in the future? Perhaps.

<u>Level II: Life Style, Public Choice, and Alternative Futures</u>

The previous discussion emphasized present patterns as seen from the perspective of the individual and the household. In this section the magnifying power of the analysis is reduced; patterns and projections on a national level are analyzed. Relationships between population, income, environmental protection costs, electricity demand, and environmental degradation are examined.

We begin with Commoner's paraphrase of Ehrlich's definition of pollution level:[4/]

$$\text{(1)} \quad \begin{matrix}\text{level of}\\\text{pollution}\end{matrix} = \begin{matrix}\text{population}\\\text{size}\end{matrix} \times \begin{matrix}\text{per capita}\\\text{consumption}\end{matrix} \times \begin{matrix}\text{environmental}\\\text{impact per unit}\\\text{of production}\end{matrix}$$

We use various assumptions about population growth and per capita consumption in the manner of Jay Forrester's World Dynamics[5/] to simulate various futures about the demand for electricity in the rest of this century. In more detail,

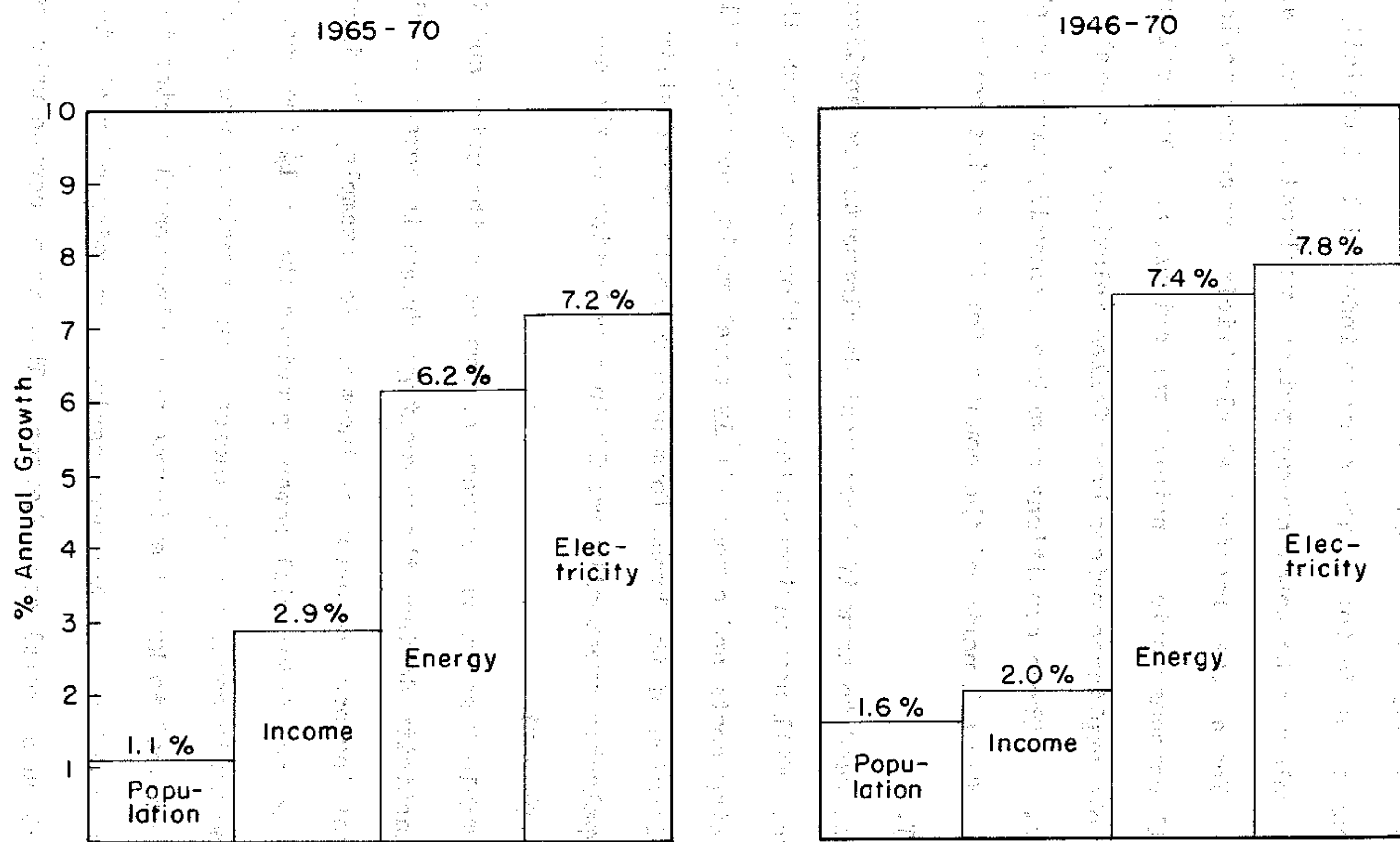
$$\text{(2)} \quad \begin{matrix}\text{demand for}\\\text{electricity}\end{matrix} = \begin{matrix}\text{population}\\\text{size}\end{matrix} \times \begin{matrix}\text{income}\\\text{influence}\end{matrix} \times \begin{matrix}\text{price}\\\text{influence}\end{matrix}$$

The income and price influences are different for each major consumer class, residential, commercial, and industrial use, so more detail is necessary (but not shown here).

By adding the amounts demanded for other uses (about 4.2% of total sales) and amounts lost in transmission (about 8.8%), we have a model to predict total generation for different population, income, and price assumptions for the rest of the century.

In the past year and a half we have been investigating the relationships between electricity use, prices, and income.[6/] Since WW II as well as since 1965 electricity use has grown faster than total energy, disposable personal income per capita (deflated), and population (see Figure 1). The electric utility industry has done well in meeting our expectations: we have had accelerating consumption at a nearly constant exponential rate, a firm supply, and declining prices. Both actual and deflated prices have declined. Table 1 shows the growth rates of total U.S. use by the three major classes of users and the rates of decline of deflated average prices.

FIGURE 1. GROWTH RATES FOR POPULATION, DISPOSABLE PERSONAL INCOME PER CAPITA DEFLATED, ENERGY, AND ELECTRICITY



Electricity has become a better buy with respect to nearly all other comparable commodities. Average industrial electricity price has declined relative to capital costs, as in Figure 2. The same relationship is true for many other factors. The average industrial electricity price has fallen relative to total energy prices, wholesale prices, and unit labor costs. The average residential electricity price has fallen relative to overall consumer prices, natural gas prices, and fuel oil and coal prices. Household appliance prices have fallen relative to overall wholesale prices. These conditions have been generally true for all consumer classes for all parts of the country for the entire period since World War II.

We need to know if these past developments are applicable to our future. Will new environmental protection costs reverse the pattern of declining costs and exponentially accelerating demand? Will, for example, modification of the broad form deed in Kentucky and strip mine regulation in Appalachia eventually result in a reduction in the need for new nuclear power plants?

Table 2 shows our current estimates of the price and income influences.[7/] An elasticity defines the percentage change in demand predicted by a one percent increase in price or income. For example, the income elasticity of +0.24 for industrial demand predicts that a 1% increase in real personal income would cause a 0.24% increase in industrial use of electricity.

We need to know how increased environmental protection will affect costs, and how this balances against economies of scale to determine the direction of total cost changes. This is of course unknowable in the winter of 1972. Table 3 reports environmental protection costs for two aspects of generation by coal, strip mine reclamation and sulphur oxide emission control. All studies cited there were published in late 1970

FIGURE 2. RATIO OF THE AVERAGE INDUSTRIAL ELECTRICITY PRICE TO THE IMPLICIT GNP PRICE DEFLATOR, NONRESIDENTIAL, FIXED INVESTMENT

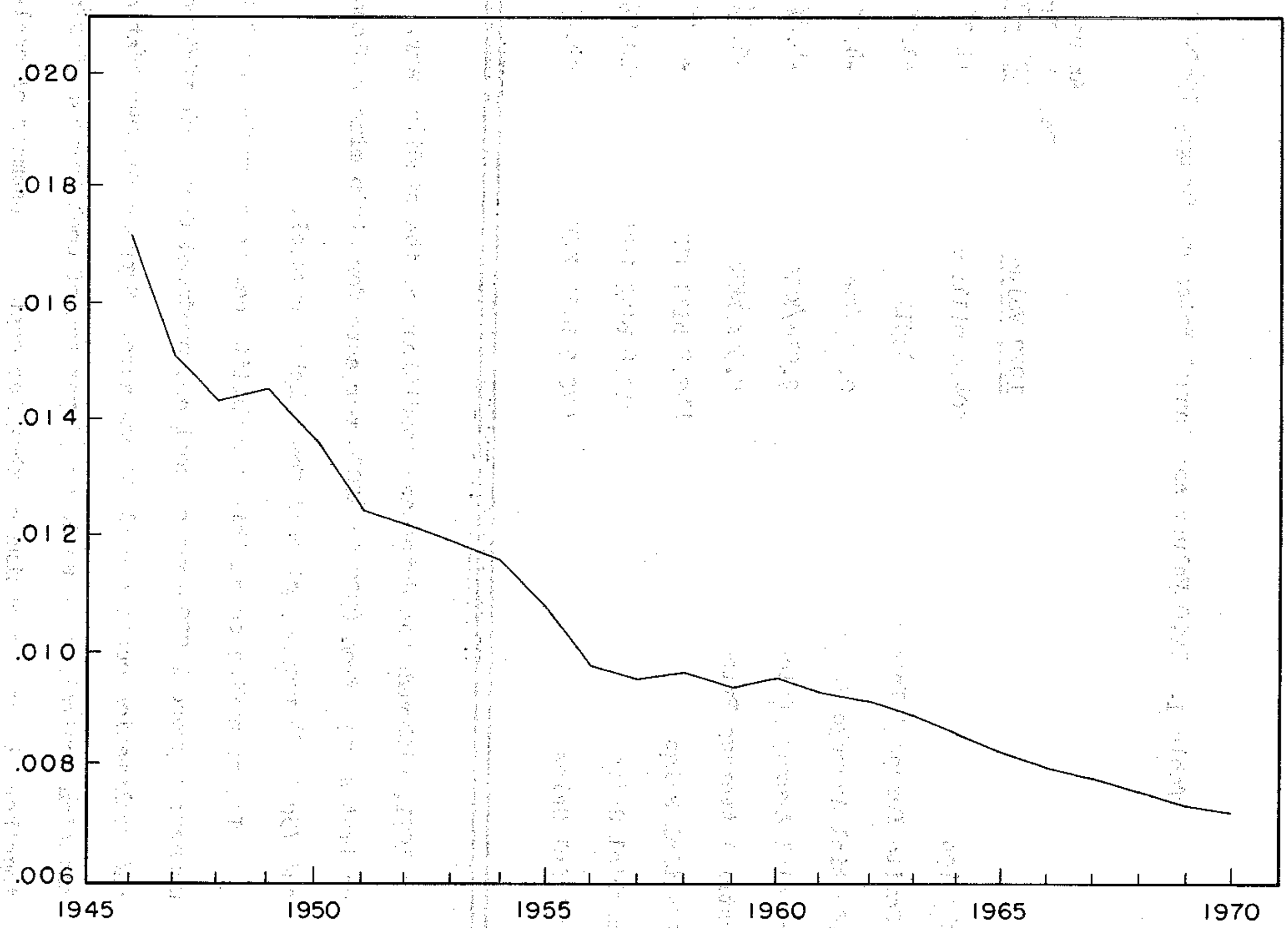


Table 1. 1970 Values and Annual Rates of Change, 1960-70

	1970 Value	Annual Rate of Change, 1960-70
Population	204.8 million	+1.3%
Per Capita Personal Income	$3911	+3.0%
Residential Average Price	2.10¢/KWH	-4.2%
Commercial Average Price	2.01¢/KWH	-4.6%
Industrial Average Price	0.95¢/KWH	-2.8%
Residential Sales	447.8 bill KWH	+8.6%
Commercial Sales	312.8 bill KWH	+10.5%
Industrial Sales	572.5 bill KWH	+5.2%

or 1971, although the dates and conditions of the studies vary. These estimates vary from $300 to $~~2000~~ 5000 per acre for strip mine reclamation and 75¢ to $4 per ton of coal for sulphur removal.

The significance of this variability can be shown in the following manner: suppose 1,000 tons of coal are produced from each stripped acre and reclamation costs are $1500 per acre. Suppose further that sulphur emission control costs would be $2 per ton of coal burned. Taking both together, it can be estimated that the cost to consumers of coal-fired generation would rise 5% to 10%.[8]

When we consider that other environmental protection costs for coal are not included here, and that we have not discussed the situation with

Table 2. Estimated U.S. Price and Income Elasticities for Per Capita Use of Electricity

Consumer Class	Price Elasticity	Income Elasticity
Residential	-1.76	+0.73
Commercial	-1.88	+0.28
Industrial	-1.90	+0.24

respect to transmission or to hydro, nuclear, oil, and gas generation, it is apparent that future environmental protection costs cannot be clearly predicted. We can, however, hypothesize various possibilities. We shall examine the implications of the following five assumptions about costs and prices: (1) continued decline at past rates of decline (see Table 4 and Figure 3), (2) decline at $\frac{1}{2}$ of past rates of decline, (3) no change from 1970 average prices, (4) a 2% of 1970 average price increase in each year, (5) a 5% of 1970 average price increase in each year. Thus in cases (4) and (5) prices would rise to 60% and 150% of 1970 prices by the year 2000.

With respect to income growth, we adopt two simple alternatives. First, we assume personal income per capita continues to grow at its past rate of 3% per year. Second, we assume growth is 3% now but will fall to zero economic growth by the year 2000. The possibility of ZIG beginning now is rejected as wholly unlikely. Income of whites exceeds income of nonwhites by more than 50%. ZIG today poses two alternatives:

FIGURE 3. PRICE ASSUMPTIONS (RESIDENTIAL) ¢/KWH, 1957-59 PRICES

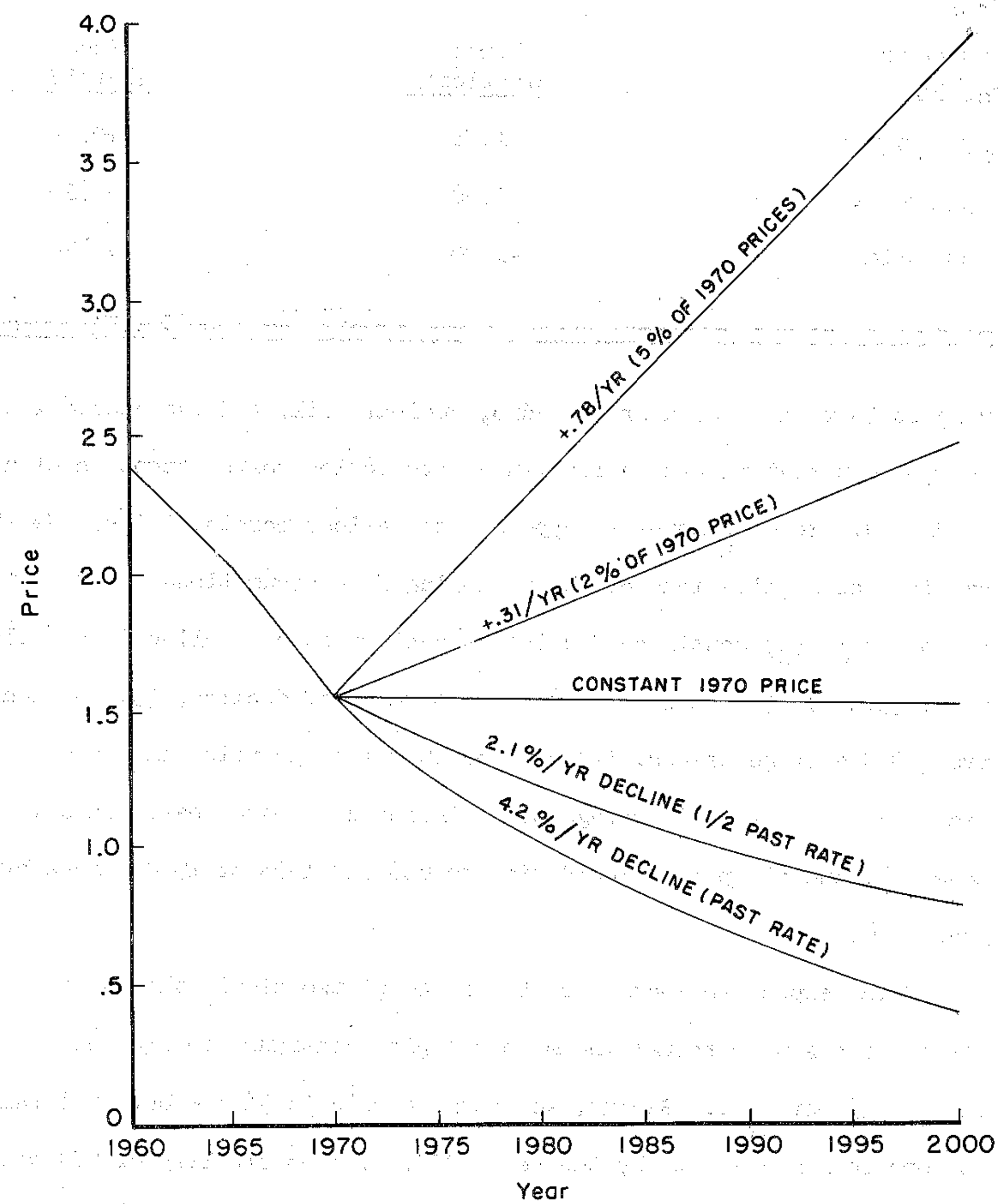


Table 3. Environmental Protection Cost Estimates

A. Strip Mine Reclamation

Estimated Cost per acre	Origin	Source
$300 - $3,000	J. A. Corgan, U. S. Bureau of Mines	Newsweek, June 28, 1971
$230 - $800	Dept. of Interior	The Economy, Energy, and the Environment, U.S. Jt. Econ. Comm.
$1200 - $2000	W. H. Miernyk, West Va. Univ.	The Strip Mining of America, Sierra Club
$5,000	U.S. Environmental Protection Agency	New York Times, Jan. 3, 1972

B. Sulphur Emission Control

Estimated Cost per Ton Coal	Origin	Source
75¢ - $1.00	National Coal Association	The Economy, . . .
$2 - $4	A. V. Slack and H. L. Falkenberry, Tenn. Valley Auth.	Electrical World, Dec. 15, 1971
$2	O. Hausgaard, N.Y. Public Service Commission	Public Utilities Fortnightly, Sept. 16, 1971

FIGURE 3. PRICE ASSUMPTIONS (RESIDENTIAL) ¢/KWH, 1957-59 PRICES

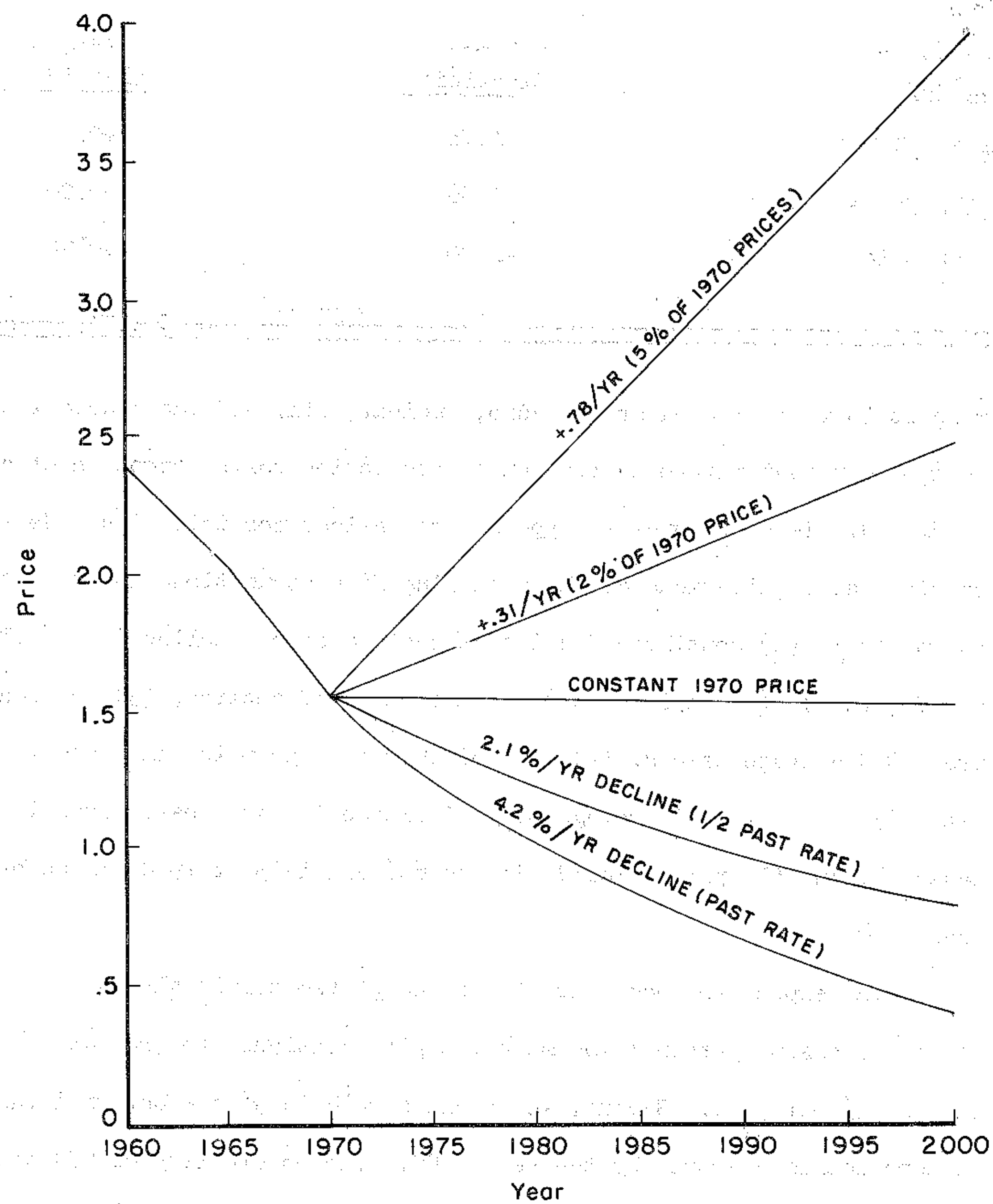


Table 4. Price Assumptions (Residential; ¢/KWH)

year	4.2%/yr decline (past rate)	2.1%/yr decline (½ past rate)	constant 1970 price	+ .031/yr (2% of 1970 price)	+ .0775/yr (5% of 1970 price)
1960	2.39	2.39	2.39	2.39	2.39
1965	2.05	2.05	2.05	2.05	2.05
1970	1.55	1.55	1.55	1.55	1.55
1975	1.25	1.40	1.55	1.71	1.94
1980	1.01	1.26	1.55	1.86	2.33
1985	0.81	1.13	1.55	2.02	2.72
1990	0.66	1.01	1.55	2.18	3.11
1995	0.53	0.91	1.55	2.33	3.50
2000	0.43	0.82	1.55	2.49	3.89

either nonwhite income remains below white income or white income falls while nonwhite income rises. Since both alternatives are unlikely, ZIG today must be rejected. The same argument applies to whites living in poverty. The ZIG assumption used here permits sufficient growth for white income to increase and for nonwhite income to increase to the same level.

This is not equivalent to a zero GNP growth assumption, since gross private domestic investment (which includes pollution control) may continue to grow with a stable personal income.[9]

Table 5. Income and Population Alternatives

	Per Capita Personal Income (dollars, 1957-59 prices)		Population (millions)	
	3.0% growth	ZIG in 2000	1.3% growth	ZPG in 2000
1960	2149	2149	180.0	180.0
1965	2478	2478	193.8	193.8
1970	2888	2888	204.8	204.8
1975	3348	3299	217.2	215.8
1980	3881	3679	231.2	226.0
1985	4499	4002	246.2	234.2
1990	5216	4248	262.1	240.2
1995	6046	4399	279.0	243.7
2000	7009	4443	297.1	244.7

Population growth has become a serious subject in the past year. Until very recently the Census Bureau has predicted U. S. population would grow at the past rate of 1.26% per year and reach about 300 million in 2000. Recently birth rates have fallen close to the ZPG level. However, it is uncertain how much of the birth rate decline is attributable to new ideas about family life and how much is attributable to our current recession. Incidentally, if two children per family became the average immediately, and immigration ceased, population would continue to grow until the ZPG level was reached in 2037 at 270 million people. We shall use two assumptions about population growth. First, we shall assume U. S.

FIGURE 4. INCOME AND POPULATION ALTERNATIVES

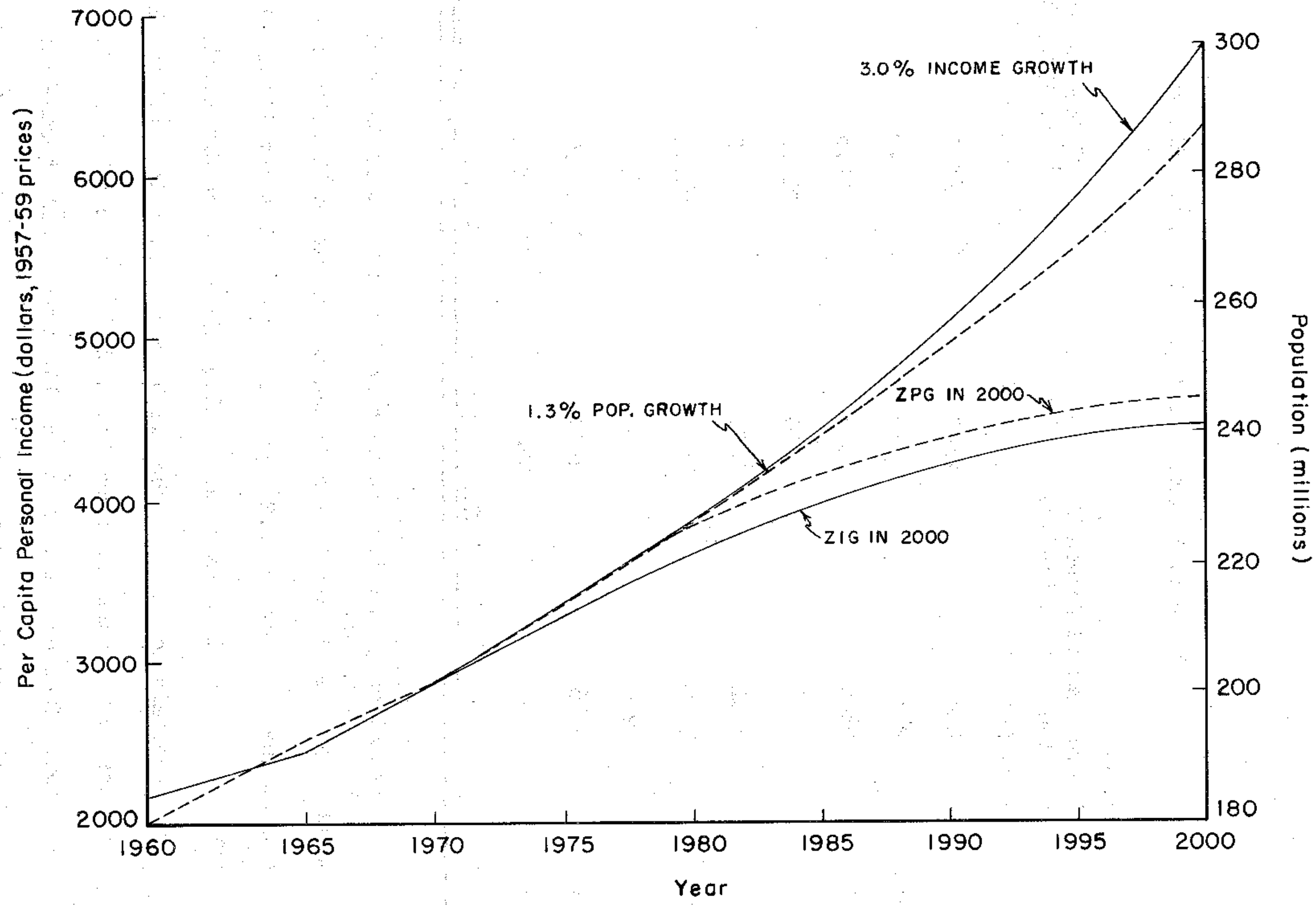


Table 6. Total Generation and Required New Plants in 2000:
Alternative Assumptions of Population, Income, and Environmental Protection Cost

Alternative Assumptions			Total	Equivalent
Population Growth	Income Growth	Electricity cost	Generation (trill KWH)	1,000 MWe Plants (new; 80% load factor)
Same	Same	Past decline rates	35.916	4913
Same	Same	1/2 past decline rates	11.547	1432
Same	Same	Constant at 1970 level	3.952	347
Same	Same	Increase at 2% 1970 level	1.665	20
Same	Same	Increase at 5% 1970 level	.733	-113
Same	ZIG	Past decline rates	28.226	3814
Same	ZIG	1/2 past decline rates	9.104	1082
Same	ZIG	Constant at 1970 level	3.134	230
Same	ZIG	Increase at 2% 1970 level	1.317	-30
Same	ZIG	Increase at 5% 1970 level	.579	-135
ZPG	Same	Past decline rates	29.589	4009
ZPG	Same	1/2 past decline rate	9.512	1141
ZPG	Same	Constant at 1970 level	3.255	247
ZPG	Same	Increase at 2% 1970 level	1.372	-22
ZPG	Same	Increase at 5% 1970 level	.604	-132
ZPG	ZIG	Past decline rates	23.299	3110
ZPG	ZIG	1/2 past decline rates	7.500	853
ZPG	ZIG	Constant at 1970 level	2.582	151
ZPG	ZIG	Increase at 2% 1970 level	1.085	-63
ZPG	ZIG	Increase at 5% 1970 level	.477	-150

population continues to grow at 1.26% per year. Second, we shall assume that population is growing at this rate now but falls to ZPG over the rest of the century.[10/]

The income and population alternatives are shown in Table 5 and Figure 4.

Thus we have five environmental protection cost paths, two income growth paths, and two population growth paths. This defines 20 alternative futures. Table 6 shows total generation in 2000 for each case. Also shown there is the equivalent number of new plants of 1,000 MWe size which could generate this power at an 80% load factor. (A 1,000 MWe plant would generate 7 billion kilowatt hours in a year.)

To complete the level of pollution equation, the environmental impact per unit of production is needed. As will be seen below, we cannot logically complete this part of the equation. However, we can illustrate its dimensions with representative effects of nuclear and coal plants of this size. A typical design for a 1,000 MWe nuclear plant will use 1,250 cubic feet of water per second for cooling. This is 31.5 billion cubic feet a year and 950 billion cubic feet over a thirty year life. Cayuga Lake in New York, for example, has a volume of 331 billion cubic feet. For rhetorical purposes we can use a "Cayuga Lake Unit" and say that a representative 1,000 MWe nuclear plant uses for cooling 1/10 of a Cayuga Lake per year and 2.8 Cayuga Lakes over its lifetime.

A representative coal plant of this size uses less cooling water; about 6% of a Cayuga Lake per year and 1.8 Cayuga Lakes over its lifetime. If each stripped acre produces 1,000 tons, the representative coal plant uses 3,150 acres per year and 94,500 acres over its life. If the coal is 2% sulphur by weight, the plant emits 63 thousand tons of sulphur per year and 1.9 million tons over its life.

However, we cannot use this kind of information to complete the equation. Each pricing assumption except the first involves increased environmental protection. When we discuss the 2% price rise case, for example, we are considering 1,000 MWe plants with dramatically less environmental effect than the plants described above. The 1,000 MWe plants are qualitatively different in each price assumption. The "dirtiest" are in the first assumption and the "cleanest" are in the last assumption.

So we must discuss the consequences of the alternatives in the context of a qualitatively different environmental impact per unit of consumption.

Four cases are selected from the twenty for somewhat detailed examination (see Table 7 and Figure 5). With the assumption of a continuation of past population and income growth and a rate of price decline 1/2 that of the past decade, we project a total generation of 11.5 trillion kilowatt hours in 2000. This is within the 10-15 trillion KWH range predicted by most industry, government, and university observers. We note that residential use has become the largest, and that total generation has become $7\frac{1}{2}$ times the 1970 level (equivalent to 1,432 new 1,000 MWe plants). We might say that this case is the base case, the view most commonly held. It seems to pre-suppose continued gains in efficiency, scale economies, and a modest increase in environmental protection.

If we suppose a continuation of past rates of price decline as well as past population and income growth, the result in 2000 is dramatically different (see "C", Table 7). Electricity prices are only about $\frac{1}{4}$ of their present values, and generation grows to a dramatic 36 trillion KWH with an equivalent 4900 new plants. Possible sources of this growth are important new uses for electricity such as electric cars or pollution

FIGURE 5. SELECTED ALTERNATIVE ASSUMPTIONS AND TOTAL GENERATION

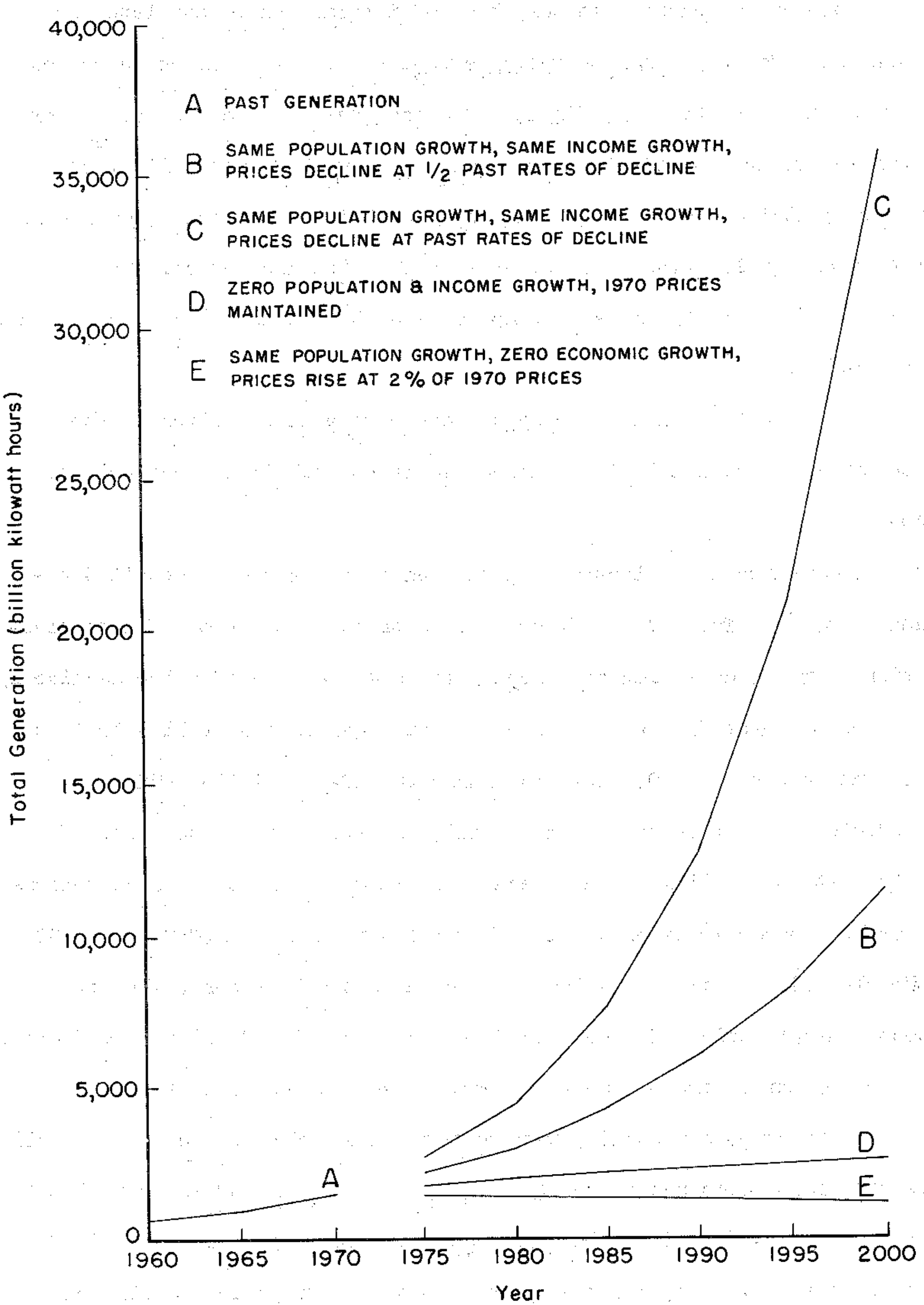


Table 7. Selected Combinations of Alternatives of Population and Income Growth and Environmental Protection Pricing Policies

Alternatives	Year	Residential Sales	Commercial Sales	Industrial Sales	Total Generatic
		(billion kilowatt hours)			
A. Past Sales and Generation	1960	189.9	113.3	340.0	752.6
	1965	281.0	202.1	433.4	1,051.6
	1970	447.8	312.8	572.5	1,526.2
B. Same population growth, same income growth, prices decline at ½ past rates of decline (base projection)	1975	754.9	489.9	825.0	2,369.0
	1980	1,080.1	689.9	1,057.1	3,235.8
	1985	1,545.2	971.7	1,354.5	4,431.1
	1990	2,210.7	1,368.4	1,735.5	6,082.9
	1995	3,162.8	1,927.1	2,223.8	8,371.0
	2000	4,525.0	2,714.0	2,849.4	11,546.8
C. Same population growth, same income growth, prices decline at past rates of decline (maximum generation projection)	1975	915.0	614.5	945.8	2,833.1
	1980	1,586.7	1,085.4	1,389.2	4,648.8
	1985	2,751.4	1,917.3	2,040.5	7,679.1
	1990	4,771.0	3,386.6	2,997.3	12,767.5
	1995	8,273.2	5,982.1	4,402.7	21,355.3
	2000	14,346.1	10,566.7	6,467.0	35,916.2
D. Zero population and income growth reached in 2000, 1970 prices maintained (an increase to a stable plateau)	1975	615.0	388.0	713.0	1,964.1
	1980	696.9	424.2	775.0	2,170.2
	1985	767.7	454.5	826.6	2,345.0
	1990	822.1	477.3	865.2	2,477.5
	1995	855.6	491.1	888.6	2,558.4
	2000	865.5	495.1	895.4	2,582.1
E. Same population growth, zero economic growth in 2000, prices rise at 2% of 1970 prices (demand rises, peaks, and declines)	1975	523.1	326.3	598.4	1,657.1
	1980	517.0	304.4	560.3	1,581.4
	1985	508.2	291.5	527.3	1,518.8
	1990	495.8	276.6	497.5	1,453.5
	1995	479.3	261.9	470.1	1,386.4
	2000	458.8	247.9	444.1	1,317.2

*For U.S. Sales; includes other uses and transmission losses but excludes exports.

control. It may also assume important new technological development such as a fusion power break-through in the near future. Finally, the combination of new uses and technology may increase the economies of scale.

The combined influences of stability in population, income, and pricing are reflected in Case D. Generation increases 29% in the first five years and 1% in the last five years. While 1970 prices are maintained, increased environmental protection is financed by cost savings from continued improvement in efficiency. Total generation is 69% higher in 2000 than in 1970, equivalent to 151 1,000 MWe plants. Per capita use rises from 7,452 KWH in 1970 to 10,552 KWH in 2000. Since the baseline case (B) defines per capita use in 2000 at 38,865 KWH, we may say that future stability forgoes an increase of 31,413 KWH.[11/] Based upon growth projections of electric intensive industries,[12/] we can conclude that the stability case of ZPG, ZEG, and constant prices implies a retardation in the growth of chemicals, metal products (cars, mobile homes), plastics, man-made fibers (nylon, rayon), drugs, and wood products (paper and cardboard). We can also conclude that the stability case implies less electric heating, air conditioning and lighting, and fewer clothes dryers and electric ranges. We can see that in the context of the preceding section, the stability case means more of us will choose to be Allens and fewer will choose to be Browns.

Case E shows an opposite extreme to maximum growth. Although population continues to grow, ZIG in 2000 and rising prices cause generation to peak and then decline. Per capita use has fallen to 4,434 KWH in 2000.

What can we conclude from these twenty alternative futures? Forrester concluded his study in this manner:

> We should be able to plot a course from exponential growth

into global equilibrium. . . If we look two or three decades hence, we see that our actions today fundamentally affect that future. If we follow programs and policies chosen with knowledge of the dynamic characteristics of social systems, better alternatives can be ahead than those to which the "natural" socio-technical-economic-political system is now leading.

We agree. The future is more a matter of choice than of prediction.

Level III: Alternative Organization of the Nature of Public Choice

The electric utility industry has sales in every county in the country (or nearly so) and generating facilities in every state. It is primarily privately owned: 3/4 of total generation is from investor-owned utilities. The remaining quarter is generated by Federal, State, Municipal, and Cooperative agencies. Industries, mines, and railways generate for their own use about 7% as much power as the electric utility industry.

The investor-owned utility is managed by a board of directors with membership typically from management staff, finance and investment banking, stockholders, law firms, industrial users, and a university.

Decisions about pricing, generating processes, plant and transmission facilities location, and permissible emissions in generation require interaction with numerous government agencies and commissions. A typical utility might work with the Federal Power Commission, the Corps of Engineers, the Bureau of Reclamation, the Environmental Protection Agency, the Atomic Energy Commission, a state regulatory commission, a state power supply agency, and State and Municipal agencies responsibile for water supply, water quality, and air quality. We will stop here at 13; undoubtedly some have been omitted.

Environmental problems are occurring with respect to each of these utility-agency interactions. In addition, many utilities must now work with one or more citizens' groups which will oppose particular utility decisions through public advocacy or government hearings.

It would be exaggerated but to the point to note that it is now possible for everyone to help manage a utility. And in this manner we would like to call your attention to two recent books by J. Vanek: The Participatory Economy and The General Theory of Labor-Managed Market Economies.[13/] Both volumes begin by defining the labor managed market economy as an economic system associated with six basic characteristics. The first characteristic is labor management: the economy is generally composed of firms managed by their labor. Some major decisions are decided directly by all workers in meetings or referenda, and other decisions are made by elected representatives. Income sharing is the second characteristic. It consists of sales revenue less all costs such as those for material, capital, and taxes. (The definition of income, however, is somewhat plastic, since it is at times defined as including intangible income and collective consumption.) Another characteristic is a market economy: firms, households, and individuals act freely and to their best advantage. Fourth, members of an enterprise enjoy usufruct, or right of use. This is related to current participation. Such rights may not be sold or negotiated, nor can assets be sold for income. Finally, freedom of employment is to be enjoyed by all citizens in the labor managed economy. These characteristics imply a decision making rule of maximization of income per laborer.

The motivation of Vanek's work is to explore the problems of modern economic organization in socialist and free enterprise countries as they relate to problems of involvement, management, control, class, status, and alienation. As such, utilities and environmental problems are not an important part of his analysis.

However, three of his conclusions are directly relevant. First, Vanek believes that a continued regulatory structure would be necessary for utilities. Second, he compares a labor-managed enterprise with ownership management in the Soviet Union and the West. Since most employees consume some of the pollution of their enterprises, Vanek argues that maximizing income per employee (using the broad definition of income to include environmental quality) should result in greater environmental protection expense than presently occurs in the Soviet Union or the West. Third, he concludes that employee management would result in lesser growth and higher real income.

To a limited extent we can perceive some of the environmental consequences of employee management for electric utilities. Most of the present managers would be managers. The same characteristics by which they have been selected for present leadership would most probably result in their being leaders in a labor-managed utility. Most of the present directors would be directors for the same reasons they are now: to promote coordination with large users and financial groups. Finally, we would see continued confrontation between citizens groups and utilities, but more frequently in conference rooms and less frequently in courts.

We would continue to have Sierra Club Conferences on Power Policy with Mr. Luce and Mr. Brower participating! Indeed, we would find we would be the same people we are now! If Vanek is right, we would find that a utility would have an easier time balancing environmental protection costs against revenue, and greater probability of trading output growth for higher real income.

Dennis Mueller, a member of the Program on Participatory Labor Managed Systems at Cornell, will be in Yugoslavia this year and next. Among the subjects he will be investigating will be the effect of labor management on environmental decision making. We await his findings with anticipation.

Conclusion

The preceding discussion has attempted to illuminate a few of the implications of alternative assumptions about life style for power generation as they relate to individual families, national policy, and the organization of utilities. There are interesting connections between the three levels of analysis which will be left for the reader to note.

We wish to conclude with the ending of an earlier section: our future is a matter of choice, and prediction should help us understand the consequences of our choices.

Notes and References

1. Barry Commoner, Michael Corr, and Paul J. Stamler, "The Causes of Pollution", Environment 13:3:2-19, April 1971; Commoner, "The Environmental Cost of Economic Growth" in U. S. Congress, Senate, Committee on Interior and Insular Affairs, Committee Print Ser. No. 92-3, Selected Readings on Economic Growth in Relation to Population Increase, Natural Resources Availability, Environmental Quality Control, and Energy Needs, Sep. 1971; Commoner, The Closing Circle, New York, 1971.

2. Oran Culberson, "The Consumption of Electricity in the United States", ORNL-NSF-EP-5, Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1971; Kent P. Andersen, "The Demand for Electricity in California -- Dimensions of Future Growth", WN-7550-NSF, RAND, Santa Monica, Aug. 1971.

3. Calculated from information in Edison Electric Institute, Statistical Year Book of the Electric Utility Industry, and U. S. Office of Business Economics, "Input-Output Structure of the U. S. Economy: 1963", Survey of Current Business, Nov. 1969, pp. 15-47.

4. "The Causes of Pollution", p. 4.

5. Jay W. Forrester, World Dynamics, Cambridge, 1971.

6. As part of the Oak Ridge National Laboratory-National Science Foundation Environmental Program at Oak Ridge. The program includes research groups studying energy, material resources and recycling, regional studies, environmental quality indices, public education, and information systems.

7. All coefficients in Table 2 are significant beyond the .001 level. For various reasons these estimates are not wholly satisfactory. We suspect further work may result in estimates about -1.1 to -1.6 with a time period of a few years necessary to reflect the total impact.

8. Based upon the analysis of the effects of a sulphur emission tax in New York in D. Chapman, T. J. Tyrrell, and T. Mount, "Electricity and the Environment: Economic Aspects of Interdisciplinary Problem Solving", presented at Amer. Assoc. for Advancement of Science annual meeting, Dec. 26, 1971.

9. The staff of the Federal Reserve Board carried out a macroeconomic simulation of the national economy with three alternative assumptions: (1) pollution control adds 5% to new equipment cost, (2) pollution control costs $3 billion a year to improve old equipment as well as the new equipment cost, and (3) no pollution control costs. They conclude that pollution control will not noticeably affect unemployment, and that per capita personal consumption would decline with maximum control (Case 2), and increase with either new equipment control (Case 1) or no control (Case 3). Personal consumption is 67% of GNP in Case 3 and 55% of GNP in Case 2. See Andrew F. Brimmer, "Economic Impact of Pollution Abatement", Selected Readings ..., pp. 425-431.

10. See Economic Report . . .; Planned Parenthood World Population, "Population Growth and America's Future", 1971; and Jack Rosenthal, "Population Growth Rate in U. S. Found Sharply Off", New York Times, Nov. 5, 1971, p. 1.

11. The "foregone increase" of 31,413 KWH per capita is 38,865 less 7,452.

12. Gerard C. Gambs and Arthur A. Rauth, "The Energy Crisis", Chemical Engineering, May 31, 1971, pp. 56-68.

13. Ithaca, 1971 and 1970.