Whither the "Energy Crisis":

Electricity Consumption and Capacity in Florida

by James P. Herden*

*Graduate Student, University of Florida. I gratefully acknowledge support received from the Public Utility Research Center of the University of Florida. Professor Sanford Berg has both encouraged and guided me in this project; sins of commission are mine and sins of ommission are his.

The popular press and national television have directed attention to an imminent "energy crisis" in the United States. Governor Askew has responded to the situation in Florida by establishing a special Energy Council to monitor the local situation and make policy recommendations. Three other recent developments underline popular and scientific interest in this area: (1) a sharply fought campaign for a Public Service Commission seat in 1972 and subtle shifts in PSC policies; (2) an antitrust suit brought against the major oil companies by Attorney General Shevin of Florida; and (3) the establishment of major research programs at the University of Florida in these areas (Public Utility Research Center and the Electric Energy Engineering Program). The purpose of this study is to outline the factors influencing electricity consumption and productive capacity in Florida over the past two decades and to forecast future demand on the basis of past relationships and expected population and price trends. The analysis suggests that the complexity of issues facing public and private decision makers is not going to diminish in the near future.

We know that historically the nation's consumption of electricity has increased at geometric rates and this trend has been projected to continue. In the short-run our energy reserves are in limited supply, although technological change and increased capacity have permitted increased per capita consumption and, until recently, falling real price. Indeed, the rate of technological innovation in the electric utility sector of the economy has been quite favorable relative to that of the private domestic sector as a whole. The average annual rate of increase in total factor productivity (output per unit of labor and capital combined) for the electric utility sector was 5.5% from 1899 to 1953 and 3.7% from 1948 to 1966. Average annual rates for these two periods in the private domestic sector were 1.7% and 2.4% respectively. With the recent period being a noteworthy exception, the average price of electricity has declined relative to the implicit price deflator for gross national product since 1946.[1] Thus, electricity has become an increasingly "better buy" relative to most products.

The obvious question is whether the present dislocations represent a minor aberration in the trend towards increased capabilities at lower real cost, or whether we are indeed entering a new era in which energy limitations will serve as an effective constraint to rising levels of real income in the United States, and Florida in particular. Consumers simply may not be able to have more electricity and more money available for other goods.

Electric energy is often taken for granted by the average consumer. Although electricity is only one component of the sum total of energy consumed in the United States, except for gasoline, the average consumer will be likely to feel a more immediate impact from a shortage of this form of energy than he would from shortages of some other energy components. The impact on consumers may be felt in the form of increased frequency of brownouts or in stiff price increases. The question is how to make regulatory policies adequately reflect both consumer preferences and technological tradeoffs facing the economy.

<u>The Nation's Electric Energy Problem</u>

The Federal Power Commission's <u>1970 National Power Survey</u> describes three major factors contibuting to an electric energy problem: (1) mounting consumer demand for electricity; (2) sharply rising costs faced by the producers; and (3) changing social values pertaining to production of electricity.[2] With respect to demand, the <u>1970 National Power Survey</u> and studies by the task force of the Committee on U.S. Energy Outlook (for the National Petroleum Council) and the energy demand panel of the Cornell-National Science Foundation Workshop on Energy and the Environment all support the so-called "double-ten" characteristic of electric energy consumption.[3] In essense, the demand for electricity in the United States has doubled nearly every ten years. Although a portion of the growth in demand can be explained by the expansion of the nation's population, it is evident that the largest factor reflecting this phenomenal growth has been the steady increase in consumption of electricity per customer.

A source of potential new demand may well come from a shift out of ultimate natural gas consumption and into consumption of electricity. Natural gas presently accounts for only 1.5% of total known U.S. energy reserves but represents 32% of total energy consumption. The current reserves-to-production ratio for natural gas indicates only a 12 year supply at 1970 usage levels.[4]

Producers of electricity are at the same time faced with increasing costs of production arising from higher fuel prices and greater plant construction expenditures. Given the substantial dependence on fossil fuels for generating purposes and the current problems in the supply of fossil fuel resources, electric producers can expect fuel prices to rise in the future. Note the recent substantial increases in the bituminous coal and residual fuel oil prices and the slight increase in the price of natural gas indicated in Figure I. Oil accounts for slightly over 2% of our known fuel reserves but is utilized to meet 44% of our total current energy demands. Some observers have noted that our shortage of oil could be filled through imports, yet this assumption is simply not realistic. Were we to import to fill our oil shortage, it has been estimated that by 1985 we would incur a substantial balance of trade drain of approximately $30 billion per year. In addition, some experts believe that world production of oil will peak out within the next few decades.[5] Finally, foreign policy implications of heavy dependence on a few Middle Eastern states are significant.

The nation's supply of coal is relatively more favorable, representing 63% of our energy reserves. Currently coal accounts for only 22% of our energy demands and therefore, represents a possible alternative to oil as a fuel for production of electricity, but there is the obvious short-run restraint of time and capital inherent in converting oil-fired plants to utilize coal.[6] Utilization of our substantial western coal reserves could open up another Appalachia in that region. Nuclear fuel is another alternative to our reserve problems; yet these fuels are somewhat limited in supply, and until the highly efficient fast-breeder reactor comes into standard use, the rate of growth in our use of this resource will increase rapidly.

As electric producers make the move to nuclear generation more problems become apparent. The larger capital investment necessary for nuclear plant construction relative to the investment necessary for construction of a conventional thermal plant of comparable capacity has put financial pressure on the producers. In particular, recent expansions of capacity through nuclear plant construction have come at a time of higher construction costs and unusually high interest rates with available capital in short supply.[7] Further aggravating the problem are the significantly longer lead times involved with nuclear plant construction, as opposed to conventional plant construction.

A major factor in the current debate is the fact that social values relating to electric energy production have been rapidly changing, impacting on the area of environmental quality standards. There are definite ecological problems associated with all forms of electric generation. Hydroelectric dams cause alteration of stream flows and water temperature and can lead to adverse nitrogen content of waters below the installation, harming fish and other wildlife. The generation of electricity through the use of fossil fuels contributes to air pollution. These damages can be reduced through utilization of low sulfur content fuels or removal of sulfur particles from flue gases at the generating plant, but both processes are expensive and can lead to increased financial pressures on the producers. Finally, inherent in nuclear production is the need for an acceptable means of disposal of radioactive wastes.[8] Both nuclear and fossil fuel generation have a great potential for causing thermal pollution of the air or nearby waterways. All of these ecological problems can be reduced substantially but not without great expense. Changing environmental standards and related litigation and licensing delays have severely hampered time schedules with respect to construction of all types of generating plants.

These observations should not be interpreted as negative. Indeed, the world's wealthiest nation cannot afford not to prevent the deterioration of the environment. However, the conflux of pressures has merged at a very inopportune time from the standpoint of electricity consumption.

In addition to the three major factors contributing to the electric energy "crisis" mentioned above, the <u>1970 National Power Survey</u> mentions various sources of delay in expansion of capacity (for example, manufacturing quality control; labor disputes and low productivity at plant sites; inadequate forecasting; insufficient advance public disclosure; changing regulatory standards; and inadequate research and development).[9] Meanwhile the demand for electric power continues to increase and the potential for a true electric energy crisis on a national scale becomes more real.

The Situation in Florida

The factors contributing to a potential electric energy crisis in Florida are many. As Table I indicates, the growth of electric energy demand in the state has been far in excess of the "double-ten" national standard. Note for example that consumption of electricity in Florida in 1962 was about 4.5 times that in 1952. Comparing the number of kilowatt-hours consumed in 1970 with that of previous years, it may be observed that consumption more than doubled since 1964. This would represent a rate of growth in demand for electricity in Florida in excess of a "double-six" standard for that period. That is, if this rate of growth in demand were to remain fixed, we could expect demand for electricity to double every six years.

Population growth, stemming from both internal multiplication of the populace and heavy migration into the state has contributed to this demand pattern. More significant has been the constant increase in consumption of electricity per customer, indicated in Table II. This table shows the number of kilowatt-hours sold per residential farm and non-farm customer and per commercial and industrial customer. The latter category of consumer is further broken down into a commercial category and an industrial category (where the information is available). Figures are given for each classification of utility (privately-owned, municipally-owned, and R.E.A) and for the statewide aggregate. Certainly a large determinant of this rapid increase in consumption per customer has been the increased utilization of domestic electric appliances (especially air conditioners) in the state.

Of important potential significance to the problem of providing sufficient capacity is the somewhat larger rate of growth seen in residential consumption as opposed to commercial and industrial consumption (see Table III). Efficiency in the generation of electricity is partially dependent upon the availability of consumers who use electricity at off-peak hours - that is, commercial, and more importantly, industrial users. For example, the phosphate industry is a major off-peak consumer of electricity and accounts for almost 53% of total industrial kilowatt-hour sales of Florida Power Corporation.[10] With residential consumption in the state rising at a rate faster than that of commercial and industrial consumption, the mix of consumer types desired for optimum efficiency could be impaired.

In addition, the increase in fuel costs is one of the prime factors affecting Florida's electric producers. Florida's geographic position makes ocean transportation of residual fuel oil less expensive relative to transportation of coal (now carried out mostly by rail).[11] Thus, residual fuel oil is the predominant fossil fuel utilized in the generation of electric power in Florida. However, residual oil production has slowed in recent years as refineries have found it more profitable to produce products of the crude oil variety (see Table IV).[12] The worldwide increase in the price of oil has had its effect on Florida's electric utilities. Florida Power Corporation, which paid $1.68 per barrel of oil under its previous supply contract, must now pay $3.07 per barrel. Officials of that utility foresee a cost per barrel of approximately $5.00 within the next four years.[13]

Recognizing the probable increase in fossil fuel prices, electric producers in the state have begun the change toward nuclear generation of electricity. The problem of delays in construction (coupled with inflationary pressures) and larger initial expenditures inherent in nuclear generation mentioned above have delayed putting such plants on-line. Florida Power's 825,000 kw capacity nuclear unit at Red Level (Crystal River) had a planned construction cost of $115 million and was to have gone on-line in April of 1972. Numerous and lengthy delays in licensing, litigation proceedings, and construction have pushed back the on-line date to December 1974, and the unit's cost is now estimated at $300 million. Due to the problems encountered in construction of this unit, construction of a second nuclear unit at Red Level has been cancelled. Because of the immediacy of current power demands, this unit must be replaced by fossil fuel units.[14]

It is evident that the factors contibuting to an energy problem throughout the nation are compounded in Florida.

Choices Facing the Regulators

For most products, consumers must depend upon the competitive market to ensure efficiency in production, low prices, reasonable quality, and innovation. Producers, in turn, remain in business only if the rate of return on their fixed investment is comparable to alternative investment opportunities in industries with similar risks. National policy for most industries supports competition, but for public utilities, a number of arguments are put forth to justify direct or indirect regulation of entry, prices, investment, and other dimensions of business behavior. The arguments most often cited to justify some form of regulation may be summarized as follows:

1. The need for franchise. Most types of public utilities are dependent upon a franchise permitting utilization of streets and public property in carrying out their services. The confusion and duplicative investment involved in the case of numerous utilities serving the same area is obvious. The franchise is, in effect, a barrier to entry and the issuance of exclusive franchise confers monopoly privileges to the utility.

2. Necessity of service. Many utilities (power, water, and gas companies, for example) provide services deemed life necessities, and continuity of such services may make regulation necessary.

3. The existence of scale economies. The technological requirements of public utilities necessitate a relatively large capital investment. The high fixed costs involved need to be spread over a large volume of customers, and this can be accomplished only through lower prices. In a competitive situation, this would lead to cutthroat price wars resulting in the bankruptcy of certain firms. Efficiency in the public utility sector can best be achieved through service by a single firm, but regulation is needed to protect customers from misuse of monopoly power.

4. Contribution to national security. Going beyond the everyday necessity of service to customers is the criteria of national security. In time of war, a strong and reliable public utility sector is of vital importance to the nation as a whole.[15] Certainly, regulation has as a major goal a financially viable and technically progressive electric utility system.

The question arises then, what signals does the competitive sector provide that may not be present for public utilities; and alternatively, how can regulation help utilities respond to the current situation in the most efficient manner from the standpoint of consumers of electricity and owners of present productive capacity?

Rate of return regulation has been more of an art than a science in the past, usually resulting from some compromise between regulators and the regulated. Depending upon which expenses are viewed as acceptable and how one calculates depreciation or treats obsolete capacity, a regulatory commission can come up with a wide variety of acceptable revenue levels. It was mentioned earlier that electric utilities have been under great financial pressure caused by construction and licensing delays coupled with rising construction and production costs. It would seem that regulatory commissions should now, more than ever, be concerned with the financial position of the firms under their jurisdiction. With available capital in short supply and general price indices rising, the costs of financing badly needed construction in the electric utility sector are on the rise. Investors expect larger returns than before simply because inflation has eaten away what returns they have received.[16] Certainly the risk factor of public utility investments is smaller than that of most industrials (due to the protective aspects of regulation), but utilities still must compete in the capital market with firms of similar risk. In addition, depreciation may simply not have been sufficient in time of inflation.

All of these factors point to the need on the part of the regulators to analyze the effects of inflation on utilities. Certainly these aspects of regulation are carried out when rate structures come up for review, but given the obvious regulatory lag of commissions, utilities may incur serious losses before alternatives are allowed. With construction of productive capacity falling behind the rapidly rising demand for electricity, commissions must closely consider the financial pressures now placed on producers.

Some state commissions have under their jurisdiction municipally owned electric utilities. Many critics of the regulatory process advocate the inclusion under state regulation of all "public" utilities whether publicly or privately owned, for the sake of consistency (the Florida Public Service Commission does not regulate municipals). Unregulated municipal utilities have often charged rates which more than reflect costs of serving particular groups of customers and have used the profits thus arising to subsidize other local governmental services which do not cover their costs.[17] Municipal utilities are for the most part opposed to state regulation as such a process would remove the aspects of local sovereignty. It is important to note, however, that the problem of supplying electricity is becoming more a regional matter than a local one, and can perhaps be effectively handled only through regional coordination.

Coordination and Interconnection of Electric Suppliers

An illustration of behavior which might not be permitted in a competitive industry but has been encouraged in regulated utilities is coordinated investment, which facilitates the full utilization of capacity. Electric producers have long realized the importance of interconnection as a means of increasing both inter-system efficiency and reliability of service.[18] Interconnection entails the physical tying in of two or more independently owned and managed electric supply systems at their bulk supply levels.[19] On some occasions, two or more firms have pooled their financial resources to construct generating capacity for mutual use.

The widespread practice of interconnection existed since well before World War II. Such practices facilitate increased efficiency by use of larger, more efficient generating units resulting in greater economies of scale than could be realized by many small unit systems. As technology has advanced, higher voltage transmission lines have been developed allowing interconnection to take place over a wider geographic area. As the interconnected systems grew to larger geographic proportions, the diversity between individual systems (in terms of load differentials) could be utilized in improving overall load factors.[20]

As World War II drew to a close, producers began to acquire more and larger generating units, as they had been unable to replace old, obsolete equipment in time of war. With implimentation of these larger units came the further awareness of the beneficial attributes of interconnection. By the late 1950's, numerous large interconnection and coordination areas were formally established. The trend toward coordination of electric systems has been bolstered within the past few years by the creation in June, 1968 of the National Electric Reliability Council (N.E.R.C.). The goal of the Council is to improve coordination efforts at all levels throughout the nation.[21]

In contrast to more formal arrangements (in the Northeast, for example), coordination within the state of Florida is carried out by an informal group of utilities, the Florida Operating Committee. Five utilities in the state, Florida Power Corporation, Florida Power and Light Company, Tampa Electric Company, the Jacksonville Electric Authority, and the Orlando Utilities Commission, are the major coordinating members of the group. The Committee was created in 1959 by the three privately owned utilities mentioned above and later included the two municipals. Each producer basically operates his system independently of the others, and there are no formal contracts relating to either power pooling or mutual plant construction. The Committee does coordinate maintenance and spinning reserve schedules of members so that there will always be sufficient reserves standing by to be utilized in the event of plant failure elsewhere. The shedding of loads is also coordinated, bringing further efficiencies to the area.[22] The "panhandle" area of Florida is served by the Gulf Power Company and lies within the coordination area known as the Southern Company System, which includes portions of Mississippi, Alabama, and Georgia.

As of 1970 there were 5 privately owned and 16 municipally owned electric utilities operating in the state in addition to 15 rural cooperatives and one Federal project (the Jim Woodruff Hydroelectric Project). Of the 16 municipally owned utilities, 11 had some form of generating capacity, while of the 15 R.E.A. cooperatives, only one produced power. All five of the privately owned utilities had generating capacity (although the Florida Public Utilities Company had only 7,703 KW of capacity).[23] The four major privately owned producers in the state plus the municipals and R.E.A. having generating capacity are indicated on the map in Figure II. It is important to note that the map shows only general areas where distribution facilities exist and should not be construed to indicate service boundaries.

There is a vast system of interconnection among Florida's electric producers. In addition, the utilities lying within the state are tied in with utilities of neighboring states. In 1967, Florida Power Corporation (a member of the N.E.R.C.) and the Southern Company made agreements ensuring a reliability of bulk power supply in this region of the country.

The steps that have been taken to ensure coordination of electric producers should, to some degree, aid in abating the potential crisis at hand by increasing economies of scale and reliability of service to consumers. Various legal battles have arisen, however, concerning interconnection of utilities in the state. It is hoped that these difficulties will soon be mitigated so that even greater scale economies and reliability can be achieved.

<u>Forecasts of Consumption and Capacity</u>: <u>1980 & 1990</u>

For the purposes of our study, we have used total ultimate kilowatt-hours sold as a proxy for electricity consumption. Ultimate kilowatt-hour sales do not include sales made by one utility to another, but since we have included final sales by all utilities having distribution facilities, we have closely approximated the level of electricity consumption within the state. Table I indicates historical levels of electricity consumption in Florida.

Consumption of electricity can be taken to be a function of a number of variables, including population, price of electricity, real income, price of competing energy sources, gross state product, electric appliance purchases, and residential construction. For simplicity we have chosen population and price of electricity as our independent variables, with the former reflecting such things as industrial demand and appliance usage. The relationship can be expressed as follows; where all variables are in logarithmic form:

$$KWH = f(POP, PRICE)$$

where KWH is the logarithm of the level of ultimate kilowatt-hour sales in a given year (expressed in thousands of kilowatt-hours); POP is the logarithm of state population in a given year (expressed in thousands of persons); and PRICE is the logarithm of the <u>real</u> average price of electricity (expressed in dollars per thousand kilowatt-hours).

Table V shows the population of Florida for each year from 1952 to 1970, and Table VI shows the average real price of electricity in the state for those years. By utilizing these data, together with Table I, it is possible statistically to estimate the relationship between KWH, and the two independent variables, POP and PRICE. The following relationship was obtained:*

$$KWH = (POP)^{2.248}_{(71.47)} \quad * \quad (PRICE)^{-0.909}_{(-9.62)}. R^2=.998,\ DW=1.07, rho=.78, \quad (I)$$

The results should not be interpreted as implying that 1 percent population growth alone will cause the consumption of electricity to rise by 2.2 percent, since other trends in the Florida economy, like the age profile of the population, income growth, and ancillary industrial and commercial consumption would have to continue as in the past. Air conditioning demands have probably affected the rate of increase of consumption over the period of observation-which would bias our projections upward. Thus, the coefficient should be viewed as a crude estimat of the relationship between consumption and population (as a proxy for many influences).

The price coefficient is in line with national estimates, and suggests that a 1% increase in the price of electricity will decrease consumption by about .9%. Of course, the use of average price for a mix of commercial, industrial, and residential consumers makes generalization difficult. Changes in block rate structures or changes induced through new building codes (as with insulation) would affect any forecasts based on this study. Nevertheless, at the risk of compounding confusion, estimates of future population and real average price for Florida can be used to project electricity consumption for 1980 and 1990 by substituting those values into equation I. At least the range of consumption can be established-although a simple time trend might be as adequate for crude bench-mark purposes.

The Statistical Abstract of the United States estimates that Florida's population will be approximately 7,721,000 in 1975 and 10,535,000 in 1985. These estimates represent a rate of growth in population of approximately 3.0% At this growth rate, the population in 1980 and 1990 will be 9,122,000 and

---

*The t-statistics are shown in parentheses. Running the regression with a constant term made no significant difference in our results.

12,262,000, respectively. According to the 1970 National Power Survey, over the nation as a whole the average price of electricity will double between 1970 and 1990. Were this trend to continue in Florida, the price of electricity would increase from \$13.99 per thousand kilowatt-hours in 1970 to \$19.79 and \$27.98 in 1990. This represents a rate of growth in real average price of approximately 3.53% annually. Since these price estimates are based on the assumptions of a national forecast, it would be helpful to make various alternative assumptions regarding price trends in Florida to determine their effect on consumption of electricity. The first alternative will be that the price of electricity will not change over the next two decades. The average price would remain at \$13.99 per thousand kilowatt-hours for 1980 and 1990. A tripling in price by 1990 would represent an annual growth rate of 5.65%, yielding an average price in 1980 of \$24.25 per thousand kilowatt-hours and in 1990, \$41.97. Lastly, we shall assume only a 50% increase in price by 1990, giving us an average price in 1980 of \$17.71 and in 1990, \$20.98. Such an increase represents a rate of growth in price of approximately 2.05% per year.

Table VII indicates the level of consumption of electricity in thousands of kilowatt-hours estimated for 1980 and 1990 (based on Equation I). There is an estimate for each assumption mentioned above. For example given a doubling in the real average price of electricity between 1980 and 1990 (i.e. a 3.53% annual rate of growth in average real price), the estimates of consumption of electricity are 67,660,300,000 kwh in 1980 and 96,784,600,000 kwh in 1990.

Given these estimated levels of future consumption, it is possible to estimate the generating capacity necessary in those years. In our model we assume capacity to be a function of consumption of electricity and do not include a time lag. We therefore assume the following relationship:

$$CAP = f(KWH)$$

where CAP is generating capacity expressed in kilowatts and KWH is consumption of electricity expressed in thousands of kilowatt-hours. Table VIII shows the levels of generating capacity in Florida from 1952 to 1970. The data of this table and that of Table I provide information sufficient to regress generating capacity (CAP) on consumption of electricity (KWH). The following equation describes the relationship between capacity and consumption:

$$CAP = e^{\underset{(-5.26)}{-2.477}} * (KWH)^{\underset{(37.86)}{1.069}}, R^2=.9951, DW=1.78, rho=.31 \quad (II)$$

with an R^2 value of .995. In other words, an increase in consumption of 1% would be associated with a 1.069% increase in capacity.

By substituting the estimates of consumption given in Table VII into Equation II, we can arrive at the estimates of generating capacity for each price assumption. These capacity forecasts are summarized in Table IX. For example, if the price of electricity were to double between 1970 and 1990 (i.e. price increases at a rate of 3.53% annually), generating capacity should be approximately 19,792,000 kw in 1980 and 29,021,400 kw in 1990.

Equation II may alternatively be written in the following manner:

$$\ln(CAP) = -2.477 + 1.069 \ln(KWH)$$

A graphic representation of this line is presented in Figure III. Here the natural logarithm of capacity is plotted against the natural logarithm of consumption, and the line most closely fitting the resulting points (line A) has a slope of 1.069 (i.e. the coefficient of the natural logarithm of KWH). A closer examination of Figure III may lead to an interesting observation pertaining to generating capacity in Florida. Note the substantial jump in capacity between the points corresponding to 1957 and 1958. The historical trend of generating capacity could be viewed as a series of abrupt jumps in capacity occurring between periods of gradual increase. Graphically, the trend could be viewed as following line U from 1952 through 1957, then jumping to line V in 1958. Lines U and V have equal slopes which are somewhat less than the slope of the long-run regression line, A. By introducing a dummy variable with a value equal to 0 from 1952 through 1957 and equal to 1.0 from 1958 through 1970, we can run a regression yielding the following equation:

$$CAP = e^{\underset{(-3.4)}{-1.23}} * (KWH)^{\underset{(43.3)}{0.987}} * e^{\underset{(4.97)}{.162}\,D}, R^2 = .9982, DW=1.79, rho-.176 \quad (III)$$

where D equals the dummy value. Alternatively expressed in natural logarithms, Equation III may be written as:

$$\ln(CAP) = -1.23 + .987 \ln(KWH) + .162(D)$$

The coefficient of ln(KWH), .987, is the slope of both lines U and V. It clould be hypothesized that a 1% increase in consumption of electricity has been associated in the short-run with a .99% change in generating capacity and that this relationship occurs in a "step" pattern over time. A coefficient of ln(KWH) which is less than 1.0 (as in this case) would indicate that Florida's producers and distributors of electricity have realized economies of scale in supplying electric power to their customers. An increase in interconnection both among Florida's producers and between our immediate coordination area and nearby "power pools" could decrease the coefficient of ln(KWH), reflecting further scale advantages, and possibly averting a possible electric energy crunch. Alternatively, the "step" pattern may reflect disequilibrium-actual capacity has been less than desired capacity in recent years because of start-up and on-line delays or because of capital rationing during inflationary periods. This financial and planning explanation yields different policy prescriptions than one which stresses purely technological developments.

Conclusion

Discussing Florida's electric energy problem is obviously easier than solving the problem itself. We have touched on the major factors contributing to the current energy problem in the nation in general and in Florida. In addition, we have made forecasts of consumption of electricity and generating capacity for the years 1980 and 1990. If our "step theory" of generating capacity in Florida is indeed a fact, the present energy crunch may stem from a badly needed, yet unfulfilled, jump in the trend of capacity. On the other hand, such long run relationships are affected by technological change, power pooling and shifting peak demands. Without analyses more sophisticted than that presented here, we are likely to continue to experience an "energy problem" in the coming decades.

TABLE I

TOTAL ULTIMATE KILOWATT-HOURS SOLD *
STATE OF FLORIDA: 1952-1970
(in thousands of KWHs)

Year	KWH	Year	KWH
1952	4,480,201	1962	19,949,998
1953	5,353,619	1963	21,820,712
1954	6,157,844	1964	23,769,828
1955	7,027,936	1965	28,140,588
1956	8,360,874	1966	30,808,128
1957	9,477,613	1967	34,095,156
1958	10,753,994	1968	NA
1959	12,330,166	1969	43,660,207
1960	13,954,407	1970	48,916,838
1961	16,900,587		

* Source: Statistics of Privately Owned Electric Utilities (1952-1970 Federal Power Commission; Statistics of Publicly Owned Electric Utilities (1952-1970), Federal Power Commission; and Annual Statistical Report, Rural Electric Borrowers, (1952-1970), Rural Electrification Administration, U.S. Department of Agriculture.

TABLE II

KILOWATT-HOUR SALES PER CUSTOMER *
(in thousands of KWHs)
1952-1971

Line Number	1952	1953	1954	1955
Residential Farm and Non-Farm				
1. Aggregate	2,280	2,660	2,900	3,160
2. Privately-Owned	2,370	2,730	2,960	3,220
3. Municipally-Owned	2,150	2,670	3,000	3,300
4. R.E.A.	1,380	1,830	2,020	2,190
Commercial and Industrial				
5. Aggregate	22,850	25,230	27,170	28,320
6. Privately-Owned	25,480	27,720	29,940	31,110
7. Municipally-Owned	9,680	12,640	14,100	15,510
8. R.E.A.	9,750	9,460	7,700	8,160
Commercial				
9. Aggregate	NA	NA	NA	NA
10. Privately-Owned	"	"	"	"
11. Municipally-Owned	"	"	"	"
12. R.E.A.	"	"	"	"
Industrial				
13. Aggregate	NA	NA	NA	NA
14. Privately-Owned	"	"	"	"
15. Municipally-Owned	"	"	"	"
16. R.E.A.	"	"	"	"

TABLE II (con't)

KILOWATT-HOUR SALES PER CUSTOMER *
(In thousands of KWHs)
1952-1971

ne mber	1956	1957	1958	1959
sidential Farm nd Non-Farm				
1. Aggregate	3,410	3,620	4,100	4,230
2. Privately-Owned	3,480	3,700	4,210	4,330
3. Municipally-Owned	3,440	3,590	3,870	4,030
4, R.E.A.	2,370	2,550	2,830	2,970
mmercial and Industrial				
5. Aggregate	31,980	35,040	36,800	41,490
6. Privately-Owned	35,180	36,990	39,600	44,790
7. Municipally-Owned	16,420	26,820	19,010	20,400
8. R.E.A.	9,200	10,550	10,210	11,550
Commercial				
9. Aggregate	NA	NA	NA	NA
10. Privately-Owned	"	"	"	"
11. Municipally-Owned	"	"	"	"
12. R.E.A.	"	"	"	"
Industrial				
13. Aggregate	NA	NA	NA	NA
14. Privately-Owned	"	"	"	"
15. Municipally-Owned	"	"	"	"
16. R.E.A.	"	"	"	"

TABLE II (con't)

KILOWATT-HOUR SALES PER CUSTOMER *
(in thousands of KWHs)
1952-1971

Line Number	1960	1961	1962	1963
Residential Farm and Non-Farm				
1. Aggregate	4,600	4,940	5,450	5,780
2. Privately-Owned	4,720	4,970	5,460	5,840
3. Municipally-Owned	4,250	5,450	6,050	6,300
4. R.E.A.	3,230	3,390	3,900	3,690
Commercial and Industrial				
5. Aggregate	44,260	45,790	52,000	54,100
6. Privately-Owned	47,810	49,980	54,720	58,330
7. Municipally-Owned	21,750	31,950	47,210	42,850
8. R.E.A.	12,410	17,030	19,000	20,820
Commercial				
9. Aggregate				
10. Privately-Owned	NA	NA	27,290	29,630
11. Municipally-Owned	NA	NA	NA	NA
12. R.E.A.	NA	10,220	11,170	11,690
Industrial				
13. Aggregate				
14. Privately-Owned	NA	NA	812,130	840,500
15. Municipally-Owned	NA	NA	NA	NA
16. R.E.A.	NA	227,210	238,830	263,390

TABLE II (con't)

KILOWATT-HOUR SALES PER CUSTOMER
(In thousands of KWHs)
1952-1971

Line Number	1964	1965	1966	1967
Residential Farm and Non-Farm				
1. Aggregate	6,210	6,440	7,120	7,380
2. Privately-Owned	6,290	6,500	7,240	7,510
3. Municipally-Owned	6,570	6,880	7,370	7,580
4. R.E.A.	4,250	4,490	5,020	5,280
Commercial and Industrial				
5. Aggregate	57,000	66,450	66,090	72,480
6. Privately-Owned	62,050	73,690	74,040	79,440
7. Municipally-Owned	44,080	46,830	45,380	53,990
8. R.E.A.	22,640	24,340	27,100	39,930
Commercial				
9. Aggregate		35,920	32,360	35,320
10. Privately-Owned	31,500	39,740	35,730	38,490
11. Municipally-Owned	NA	25,860	23,640	25,590
12. R.E.A.	12,080	12,650	16,000	24,260
Industrial				
13. Aggregate		895,210	968,840	740,110
14. Privately-Owned	868,910	927,470	1,026,310	1,098,890
15. Municipally-Owned	NA	925,580	899,090	300,850
16. R.E.A.	271,960	260,370	247,510	390,000

TABLE II (con't)

KILOWATT-HOUR SALES PER CUSTOMER *
(in thousands of KWHs)
1952-1971

Line Number	1960	1961	1962	1963
Residential Farm and Non-Farm				
1. Aggregate	4,600	4,940	5,450	5,780
2. Privately-Owned	4,720	4,970	5,460	5,840
3. Municipally-Owned	4,250	5,450	6,050	6,300
4. R.E.A.	3,230	3,390	3,900	3,690
Commercial and Industrial				
5. Aggregate	44,260	45,790	52,000	54,100
6. Privately-Owned	47,810	49,980	54,720	58,330
7. Municipally-Owned	21,750	31,950	47,210	42,850
8. R.E.A.	12,410	17,030	19,000	20,820
Commercial				
9. Aggregate				
10. Privately-Owned	NA	NA	27,290	29,630
11. Municipally-Owned	NA	NA	NA	NA
12. R.E.A.	NA	10,220	11,170	11,690
Industrial				
13. Aggregate				
14. Privately-Owned	NA	NA	812,130	840,500
15. Municipally-Owned	NA	NA	NA	NA
16. R.E.A.	NA	227,210	238,830	263,390

TABLE III

TOTAL KWHs SOLD: RESIDENTIAL & COMMERCIAL and INDUSTRIAL CATEGORIES *
1961-1970

ear	KWHs Sold To Residential Customers (thousands of KWHs)	KWHs Sold To Commercial and Industrial Customers (thousands of KWHs)
1961	7,249,944	8,687,777
1962	8,522,528	10,506,847
1963	9,474,703	11,197,224
1964	10,732,781	12,439,659
1965	11,708,225	14,889,138
1966	13,499,511	15,605,801
1967	14,735,132	17,626,952
1968	NA	NA
1969	20,650,666	20,182,799
1970	23,710,969	22,317,352

Source: Statistics of Privately Owned Electric Utilities (1961-1970), Federal Power Commission; Statistics of Publicly Owned Electric Utilities (1961-1970), Federal Power Commission; and Annual Statistical Report, Rural Electric Borrowers, (1961-1970), Rural Electrification Administration, U.S. Department of Agriculture.

TABLE IV

DOMESTIC SUPPLY OF RESIDUAL FUEL OIL, 1961-1970*

Year	Crude Runs to U.S. Refineries, in 10^6 Barrels	Residual Oil Yield,%	Residual Oil Output, in 10^6 Barrels	Total Domestic Consumption in 10^6 Barrels
1961..	2,987.2	10.6	315.6	548.7
1962..	3,069.6	9.6	295.7	545.8
1963..	3,170.7	8.7	275.9	538.9
1964..	3,223.3	8.3	266.8	554.6
1965..	3,300.8	8.1	268.6	587.0
1966..	3,447.2	7.7	264.0	626.4
1967..	3,582.6	7.7	276.0	651.9
1968..	3,774.4	7.3	275.8	668.2
1969..	3,879.6	6.9	265.9	721.9
1970..	4,005.6	6.4	257.5	804.2

Source: <u>1970 National Power Survey</u>. Federal Power Commission. vol. I, page I-4-18.

TABLE V

ANNUAL POPULATION OF FLORIDA: 1952-1970 *
(in thousands)

Year	Population	Year	Population
1952	3,118	1962	5,392
1953	3,284	1963	5,532
1954	3,505	1964	5,781
1955	3,747	1965	5,954
1956	4,047	1966	6,104
1957	4,372	1967	6,242
1958	4,630	1968	6,433
1959	4,808	1969	6,641
1960	4,952	1970	6,789
1961	5,205		

Source: THE 1971 STATISTICAL ABSTRACT of THE UNITED STATES BUREAU of THE CENSUS, U.S. DEPARTMENT of COMMERCE.

TABLE VI

REAL PRICE OF ELECTRICITY IN FLORIDA: 1952-1970 *
(in dollars per thousand kilowatt-hours)

Year	Price	Year	Price
1952	$30.8076	1962	$20.8850
1953	$28.9209	1963	$20.4411
1954	$28.6734	1964	$20.2195
1955	$28.5531	1965	$17.4355
1956	$27.7672	1966	$17.5710
1957	$27.8131	1967	$16.4924
1958	$25.4841	1968	NA
1959	$23.6899	1969	$14.7994
1960	$23.0852	1970	$13.9908
1961	$22.0420		

* Source: Statistics of Privately Owned Electric Utilities (1952-1970 Federal Power Commission; Statistics of Publicly Owned Electric Utilities (1952-1970), Federal Power Commission; and Annual Statistical Report, Rural Electric Borrowers, (1952-1970), Rural Electrification Administration, U.S. Department of Agriculture.

Real price of electricity was computed by dividing total revenues from sale of ultimate kilowatt-hours by total number of kilowatt-hours sold and deflating that quotient by the implicit GNP deflator (1958 = 1.0).

TABLE VII

FORECASTS OF CONSUMPTION OF ELECTRICITY: 1980 & 1990

nual Rate Growth in Price	Consumption Estimates (kwh x 1000) For: 1980	1990
3.53% (price increases by 100% from 1970 to 1990)	67,660,300	96,784,600
0.00% (no change in price from 1970 to 1990)	92,704,100	181,694,000
5.65% (price increases by 200% from 1970 to 1990)	56,240,200	66,957,300
2.05% (price increases by 50% from 1970 to 1990)	74,829,700	125,700,000

TABLE VIII

GENERATING STATION CAPACITY *
(in KW)

Year	Capacity	Year	Capacity
1952	1,063,396	1962	5,357,393
1953	1,330,266	1963	5,835,293
1954	1,490,751	1964	6,826,913
1955	1,748,651	1965	8,028,355
1956	1,906,861	1966	8,847,665
1957	2,181,861	1967	9,644,806
1958	3,004,095	1968	NA
1959	3,339,467	1969	11,953,570
1960	3,756,157	1970	13,111,265
1961	4,822,214		

* Source: Statistics of Privately Owned Electric Utilities (1952-1970) Federal Power Commission; Statistics of Publicly Owned Electric Utilities (1952-1970), Federal Power Commission; and Annual Statistical Report, Rural Electric Borrowers, (1952-1970), Rural Electrification Administration, U.S. Department of Agriculture.

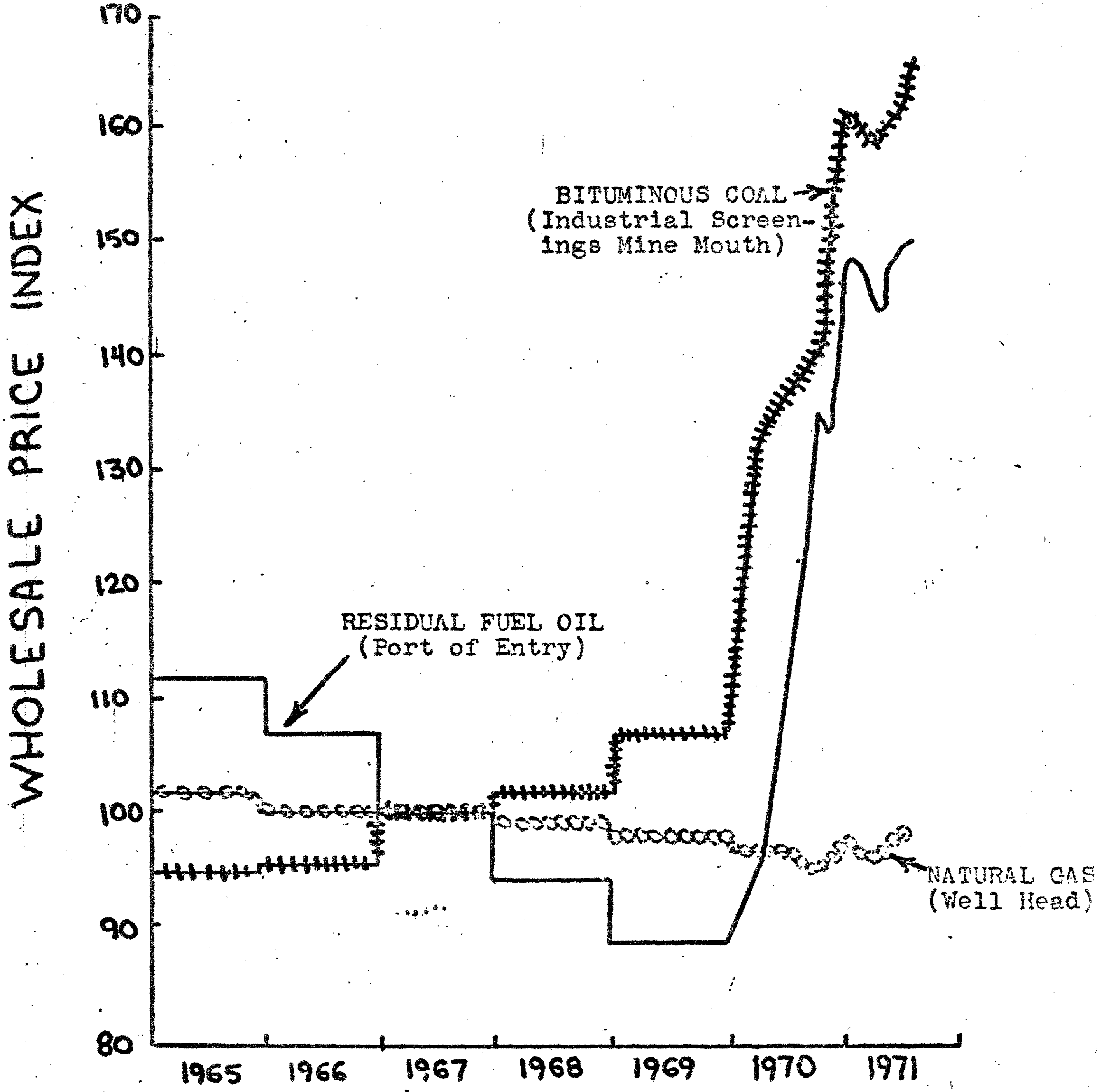
TABLE IX

FORECASTS OF GENERATING CAPACITY: 1980 & 1990

Annual Rate of Growth in Price	Generating Capacity Estimates (in kw) For: 1980	1990
3.53% (price increases by 100% from 1970 to 1990)	19,792,100	29,021,400
0.00% (no change in price from 1970 to 1990)	27,715,200	56,908,800
5.65% (price increases by 200% from 1970 to 1990)	16,242,600	19,572,500
2.05% (price increases by 50% from 1970 to 1990)	22,042,600	38,380,300

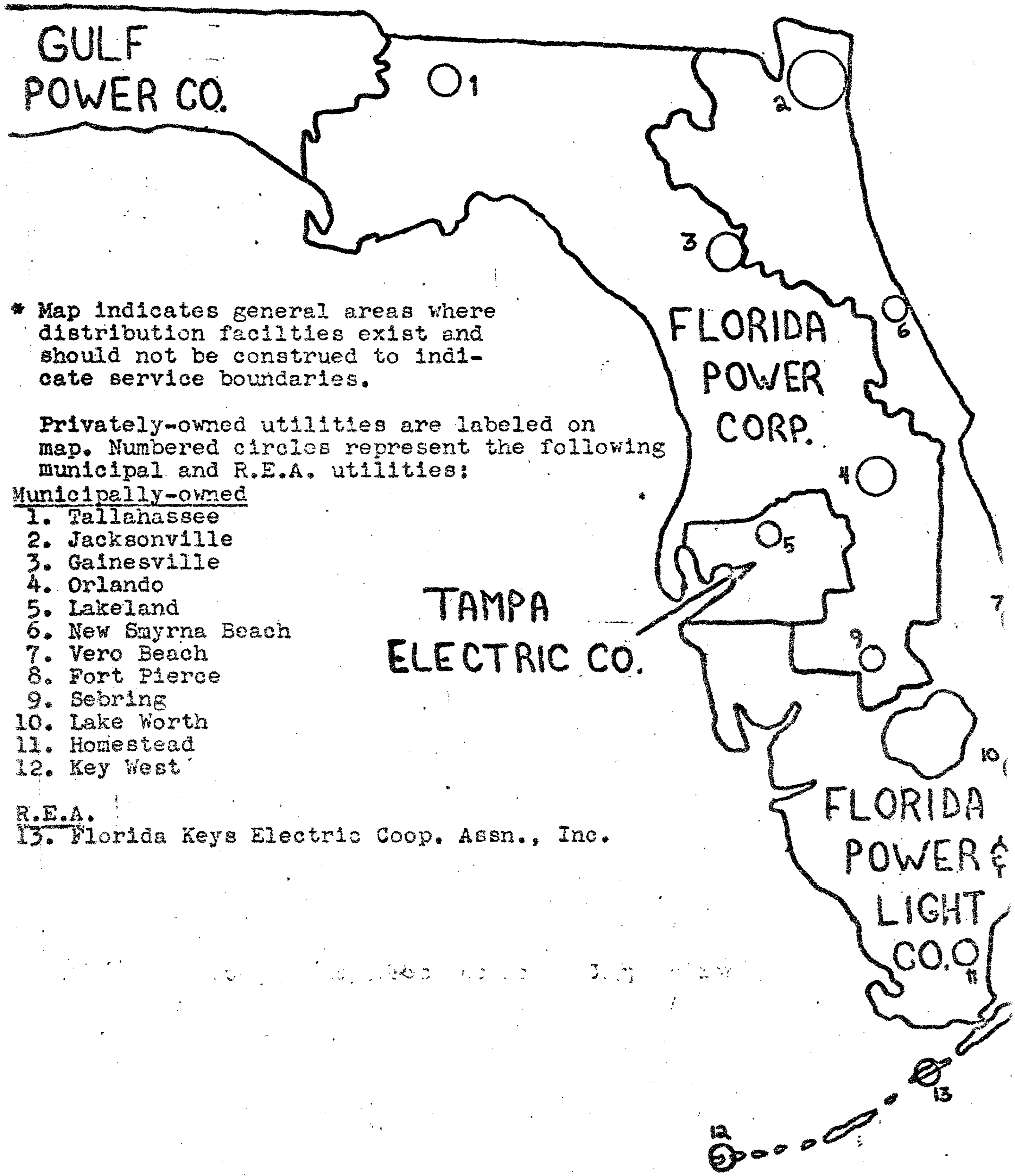
FIGURE I

RELATIVE CHANGES IN THE WHOLESALE PRICE
INDEX OF FOSSIL FUELS
Deflated by the Industrial Commodities Wholesale
Price Index (Index 1967=100)



Source: 1970 National Power Survey. Federal Power Commission. vol.I, page I-4-28.

FIGURE II
FLORIDA ELECTRIC UTILITIES WITH
GENERATING CAPACITY *



* Map indicates general areas where distribution facilties exist and should not be construed to indicate service boundaries.

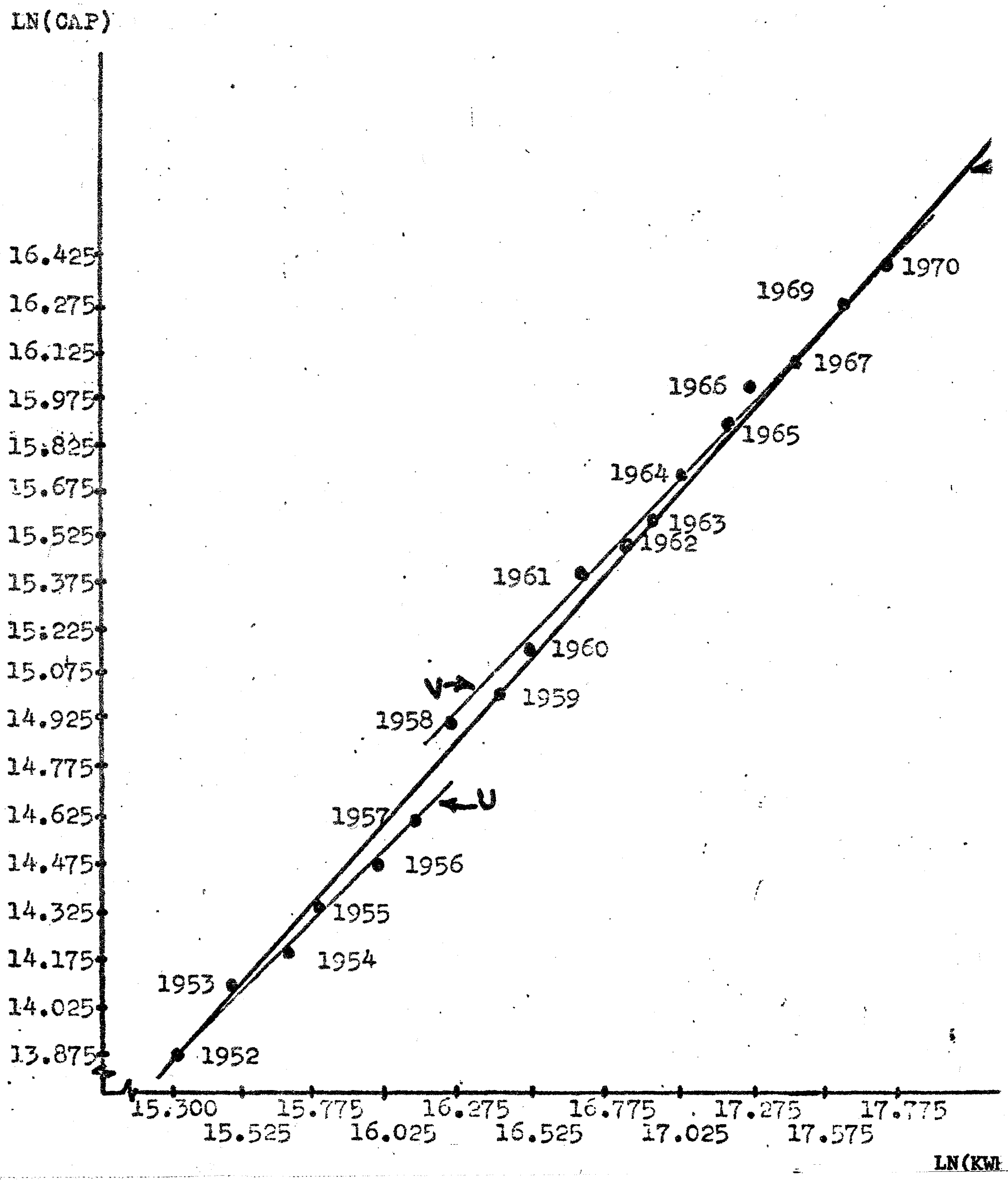
Privately-owned utilities are labeled on map. Numbered circles represent the following municipal and R.E.A. utilities:

<u>Municipally-owned</u>
1. Tallahassee
2. Jacksonville
3. Gainesville
4. Orlando
5. Lakeland
6. New Smyrna Beach
7. Vero Beach
8. Fort Pierce
9. Sebring
10. Lake Worth
11. Homestead
12. Key West

R.E.A.
13. Florida Keys Electric Coop. Assn., Inc.

FIGURE III

SCATTER DIAGRAM: LN(CAP) vs. LN(KWH)



BIBLIOGRAPHY

Bary, Constantine W. Operational Economics of Electric Utilities. New York: Columbia University Press, 1963.

Chapman, Duane., Timothy Tyrrell, and Timothy Mount. "Electricity Demand Growth and the Energy Crisis." Science, vol. 178, no. 4062 (Nov. 17, 1972).

Clemens, Eli Winston. Economics and Public Utilities. New York: Appleton-Century-Crofts, Inc., 1950.

Farris Martin T. and Roy J. Sampson. Public Utilities: Regulation, Management, and Ownership. Boston: Houghton Mifflin Co., 1973.

Federal Power Commission. The 1970 National Power Survey. Washington: U.S. Government Printing Office, 1971.

____________________. Statistics of Privately Owned Electric Utilities:1970. Washington: U.S. Government Printing Office, 1971.

____________________. Statistics of Publicly Owned Electric Utilities: 1970. Washington: U.S. Government Printing Office, 1971.

Florida Power Corporation. 1972 Annual Report. St. Petersburg: 1973.

____________________. Ten Year Statistical Report: 1962-1972. St.Petersburg: 1973.

Kahn, Alfred E. The Economics of Regulation: Principles and Institutions, vol. 2. New York: John Wiley and Sons, Inc., 1971.

Lerner, Eugene M. and Joseph S. Moag. "Information Requirements for Regulating Decisions." Rate of Return Under Regulation: New Directions and Perspectives, ed. Harry M. Trembling and R. Hayden Howard. East Lansing: Michigan State University, 1969.

Scanlow, John P. "Inflation and the Rate of Return." Rate of Return Under Regulation. ____________________.

Simpson, John W. "Perspectives on Power and Policy." Public Utilities Fortnightly (March 29, 1973).

United States Department of Agriculture (Rural Electrification Administration). Rural Electric Borrowers:1970. Washington: U.S. Government Printing Office, 1971.

Vennard, Edwin. The Electric Power Business. New York: McGraw-Hill, 1970.

FOOTNOTES

1. Alfred E. Kahn, The Economics of Regulation: Principles and Institutions, vol. 2 (New York: John Wiley and Sons, Inc., 1971), p. 99-100.

2. Federal Power Commission, The 1970 National Power Survey (Washington: U.S. Government Printing Office, 1971), p. I-1-1.

3. Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crisis," Science, vol. 178, no. 4062 (Nov. 17, 1972), p. 703.

4. John W. Simpson, "Perspectives on Power and Policy," Public Utilities Fortnightly (March 29, 1973), p.34.

5. Ibid., p. 34-35.

6. Idem.

7. Federal Power Commission, The 1970 National Power Survey, p. I-1-5.

8. Martin T. Farris and Roy J. Sampson, Public Utilities: Regulation, Management, and Ownership (Boston: Houghton Miflin Co., 1973), p. 321-323.

9. Federal Power Commission, The 1970 National Power Survey, p. I-1-5.

10. Florida Power Corporation, Ten Year Statistical Report: 1962-1972 (St. Petersburg, 1973), p.22.

11. Federal Power Commission, The 1970 National Power Survey, p. IV-1-28.

12. Ibid. p. II-3-45.

13. Florida Power Corporation, 1972 Annual Report (St. Petersburg, 1973), p. 13.

14. Idem.

15. Eli Winston Clemens, Economics and Public Utilities (New York: Appleton-Century-Crofts, 1950), p. 21-33.

16. John P. Scanlon, "Inflation and the Rate of Return," Rate of Return Under Regulation: New Directions and Perspectives, p. 177.

17. Clemens, op. cit. p. 576.

18. Edwin Vennard, The Electric Power Business (New York: McGraw-Hill, 1970), p. 253.

19. Constantine W. Bary, Operational Economics of Electric Utilities (New York: Columbia University Press, 1963), p. 143.

20. Vennard, op. cit., p. 265.

21. Federal Power Commission, The 1970 National Power Survey, p. I-17-14.

22. Ibid., p. II-3-33,34.

23. Federal Power Commission, Statistics of Privately Owned Electric Utilities: 1970 (Washington: U.S. Government Printing Office, 1971).
Federal Power Commission, Statistics of Publicly Owned Electric Utilities: 1970 (Washington: U.S. Government Printing Office, 1971).
and Rural Electrification Administration, U.S. Department of Agriculture, Rural Electric Borrowers: 1970 (Washington: U.S. Government Printing Office, 1971).