DEMAND FOR ELECTRICITY IN TAMIL NADU - A TREND ANALYSIS

By

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I. INTRODUCTION

Electricity today is the most preferred form of energy and the demand for it has been growing at rates much faster than the other forms of energy. Kapur (1980) states that adequate availability of electricity is an essential pre-requisite to development as also to the continued satisfactory functioning of industry and agriculture. Industrial Sector is the largest consumer accounting for a share of about 62 per cent of electricity consumption and agriculture accounts for 15 per cent in India.

It has been an almost universal phenomenon in all developing countries that there is a high growth rate in electricity demand. India is no exception and use of electricity in all sectors of the economy has been registering a steady growth in the last three decades. (Chandran, 1981).

In India, the power generating industry is one of the fast growing sectors of the economy. According to Chakravarthy (1982) the Government devoted special attention to the development of power resources during the Five Year Plans. The capital outlay on power development was Rs.30 crores in the First Plan period. It has increased to Rs.19,265 crores in the Sixth Five Year Plan.

The installed capacity of power generation has grown from 2,000 MW at the beginning of the First Five Year Plan to about 29,000 MW in 1980. The power generation has increased from 55,825 MKWh in 1970 - 71 to 1033281 MKWh in 1978 - 79 (Indian Express, 1980).

The total consumption of power registered a significant increase over the years from 43,724 MKWh in 1970 - 71 to 95,421 MKWh in 1978 - 79. Per capita consumption of electricity is one of the yardsticks for measuring the standard of living of the people. The per capita consumption has increased from 78 KWh in 1969 to 134 KWh in 1979-80 (Krishnaiah and Rao, 1980). One of the paradoxes of the power situation in the country at the moment is that inspite of an appreciable improvement in generation, it continues to the scarce for many consumers. From the middle of 1972, the nation has been virtually in the grip of a power famine.

Tamil Nadu has achieved spectacular progress in the generation and utilization of electrical energy in the country. The outlay on power generation in Tamil Nadu during the First Five Year Plan was Rs.3,028 lakhs and it has increased to Rs.96,900 lakhs in the Sixth Five Year Plan (The perspective plan for Tamil Nadu 1974 - 84).

The installed capacity of electricity in Tamil Nadu was 1,909 MW in 1978 - 79, and it ranks third in installed capacity. The power generation in the same period is 6,607 MU and Tamil Nadu ranks third in power generation also. The per capita power consumption in Tamil Nadu is 181 KWh in 1979 - 80 and it ranks fifth in per capita power consumption. During seventies, invariably in all the years, there was excess demand for electricity over supply. It is evidenced from the purchase of electricity from the surplus states in these years. For instance, in 1978-79, the power generation was only 6,607 MU and the consumption of electricity was 8,107 MU showing an excess demand of 1,500 MU. The consumption of electricity by industrial and agricultural sectors is continuously increasing. About 65 per cent of the total electricity was consumed by agricultural and industrial sectors of which industrial sector consumed 47 per cent while the consumption of agricultural sector was 18 per cent during 1978 - 79. (Tamil Nadu - An Economic Appraisal, 1979).

The demand for electricity is different from the demand for other commodities as it is not the function of price,

taste, and preference and is determined by the growth of the economy. So a study on the demand for electricity will help to integrate the growth of the economy with the consumption of electricity in many complex ways. The current study on the trend analysis of demand for electricity in Tamil Nadu seeks to highlight the causes for the growth in the demand for electricity in Tamil Nadu during 1970 - 79. It aims at:

1. Finding out the extent of electricity generation by different stations and sources in Tamil Nadu.
2. Analysing the sectorwise consumption of electricity.
3. Estimating the demand function for electricity.
4. Finding out the growth in the demand for electricity during the specified period, and
5. Analysing the relationship between the demand for electricity and the growth of the economy in terms of agriculture and industry.

The study specifically tests the hypothesis that the demand for electricity is directly releated to the growth of the economy in terms of agriculture and industry.

The data base of the study is derived from the statistics available in the official and non-official sources like India - A Reference Manual - Compiled by the Research and Reference Division - Ministry of Information and Broadcasting Government of India, Power Engineer's Handbook - Published by Tamil Nadu Electricity Board Engineers' Association, Tamil Nadu - An Economic Appraisal Published by Finance Department, Government of Tamil Nadu and The Hindu Survey of Indian Industry.

The present study does not attempt an analysis of the supply position in regard to power. Nor does it purport to cover the cost - price relationships. It is confined to an analysis of the demand for electricity. This tries to highlight the causes for the growth in the demand for electricity in Tamil Nadu during the period 1970 - 79. It attempts to estimate the demand for electricity and project its future dimensions. The findings of the study are expected to evoke interest in understanding the nature of demand for infrastructural utilities in the economy.

II. REVIEW OF LITERATURE

The literature relating to the study on the 'Demand for electricity in Tamil Nadu,' is reviewed under the following heads:

1. Power in India.
   a. Five Year Plans and power,
   b. Power generation - Statewise,
   c. Power generation - Regionwise,
   d. Consumption of power - Sectorwise, and
   e. Consumption of power - Statewise.
2. Related Studies,
   a. Demand for Energy in India 1960 - 75
   b. Energy and Development, and
   c. World Bank Research in Electric Power.

1. Power in India:

Electricity is a basic infrastructure on which the economic and social development of any country largely depends. The infrastructure required for industrial development

can be built only on a sound and extensive net work of power supply. Application of electricity in different fields of activity increases productivity and reduces human drudgery. Electricity supply in the pre-independence era was mostly in the hands of private enterprise. No organised effort was made by the Government for electricity development in the country. The need for integration of electricity development with the development of in other sectors was realised only in 1948, when the Government passed the Industrial Policy Resolution and stated that the generation and distribution of electricity would be the exclusive responsibility of the States (Krishnaia and Rao, 1980).

a. Five Year Plans and Power:

Power generation programmes made phenomenal progress with the advent of the Five Year Plans. During the First Five Year Plan (1951 - 56) construction of a number of major river valley projects like Bhkra - Nangal, Damodar valley, Hirakud and Chambal valley were taken up and these projects stepped up both food production and power generation. At the end of the First Plan the generation capacity stood at 34.2 lakh KW.

The emphasis in the Second Five Year Plan was on the development of basic and heavy industries, and the related need to step up power generation. The installed capacity at the end of the Second Plan reached the 57 lakhs KW mark.

The emphasis in the Third Five Year Plan was on extending power supply to rural areas. A significant development in this phase was the emergence of Inter - State grid system. The country was divided into five regions to promote power development on a regional basis. A Regional Electricity Board was established in each region to promote integrated operation of the constituent power systems.

The three Annual Plans that followed the Third Five Year Plan aimed at consolidating the programmes initiated during the Third Five Year Plan.

The Fourth Five Year Plan was marked by Central participation in expansion of power generation programmes in strategic locations to supplement the activities in the State Sector.

The progress during the period covering the Third Five Year Plan, the three Annual Plans and the Fourth Five Year Plan was substantial, with installed capacity rising to 184.6 lakh kw., comprising 69.7 lakh kw from hydro electric projects and 108.5 lakh kw from thermal projects and the balance of 6.4 lakh kw from nuclear plants.

The main empnasis of the power programme in the Fifth Five Year Plan was on speeding up the construction and commissioning of power generation projects and improving the utilisation of the available capacities. Power stations with a total installed capacity of 53 lakh kw were commissioned during the first three years of the plans to bring the total installed capacity in the country to about 237 lakh kw. A number of power stations are in different stages of construction and it was expected that an installed capacity of about 240 lakh KW will be demanded during 1977-78, bringing the total installed generating capacity in the country to about 260 lakh kw at the end of 1978. A sum of Rs.19,265 crores has been allocated during the Sixth Plan.

It envisages an addition of 19666 MW during the five years ending March 1985. Chakravarthy (1982) laments that till now enough attention has not been paid to build a transmission network. Only now the National Thermal Power Corporation has taken up the construction of 400 KV lines.

Even though successive Five Year Plans have emphasised the need to strengthen the power sector, the additions to installed capacity have not been satisfactory. Demand has been outstripping availability of power every year.

b. Power Generation - Statewise:

The details of Statewise installed capacity and power generation in 1979 - 80 are given in Table 2.1

Table 2.1

STATEWISE INSTALLED CAPACITY AND POWER GENERATION IN INDIA 1979-80

S.No.	State/Union Territories Board/Corporation.	Installed Capacity		Power Generation	
		In MW	%	In Million KWh	%
	States				
1.	Andhra Pradesh	1879	6.9	6807	6.4
2.	Assam	142	0.5	511	0.5
3.	Bihar	845	3.1	2615	2.5
4.	Gujarat	2251	8.2	8868	2.5
5.	Haryana	362	1.3	531	0.5
6.	Himachal Pradesh	105	0.4	338	0.3
7.	Jammu and Kashmir	199	0.7	689	0.7
8.	Karnataka	1320	4.8	5411	5.0
9.	Kerala	1012	3.7	5118	4.9
10.	Madhya Pradesh	1379	5.0	6087	5.8
11.	Maharashtra	3824	14.0	17491	16.6
12.	Orissa	880	3.2	2484	2.4
13.	Punjab	536	2.0	1628	1.5
14.	Rajasthan	491	1.8	2245	2.1
15.	Tamil Nadu	2719	9.9	9915	9.4
16.	Utter Pradesh	3329	12.2	11227	10.6
17.	West Bengal	1556	5.7	5224	5.0
18.	Union Territories	854	3.1	3364	3.2
19.	Bhakra Management Board	1205	4.4	6663	6.3
20.	Damodar Valley	1421	5.2	4618	4.4
21.	Beas Construction Board	900	3.3	333	3.2
	Others	144	0.6	358	0.3
	All India	27358	100	105525	100

Source: Commerce Annual Vol. 147, P.337, 1980.

It may be seen from the table (2.1) that the State of Maharashtra stands first with an installed capacity of 3,824 MW (14 per cent) followed by Uttar Pradesh and Tamil Nadu. The installed capacity of Himachal Pradesh is the lowest 105 MW (0.4 per cent). Tamil Nadu ranks third with an installed capacity of 2,710 MW (9.9 per cent). In power generation also Maharashtra ranks first (16.6 per cent) and Tamil Nadu ranks third. (9.4 per cent)

C. Power Generation - Regionwise:

The total electrical energy generated in different regions from various sources namely., hydel, thermal and nuclear during 1977 - 78 is furnished in Table 2.2.

Table 2.2

ELECTRICAL ENERGY GENERATED IN DIFFERENT REGIONS IN INDIA 1977-78

(in m.u.)

Region	Hydel	Thermal	Nuclear	Total
Utilities.				
Northern	11349	11169	198	22716
Western	8650	18427	2075	29152
Southern	14846	7695	-	22541
Eastern	2910	13106	-	16016
North Eastern	245	616	-	861
Total All India Utilities.	38000	51013	22731	91286
Non-Utilities	-	7400	-	7400
Grand Total All India	38000	58413	2273	98686

Source : INDIA - A Reference Manual - Compiled by the Research And Reference Division - Ministry of Information And Broadcasting - Government of India, P.270 - 1979.

It is clear from Table 2.2 that hydel and thermal stationstogetner account for about 95 per cent of the total installed capacity. Only of late the country has turned towards nuclear power stations.

d. Consumption of Power - Sectorwise:

General power consumption in India from 1960-79 isgiven in Table 2.3.

Table 2.3

POWER CONSUMPTION IN INDIA 1960-79

(In percentage)

Item	1960 - 66	1974 - 75	1978-79
Industrial	69	62	61
Agricultural	6	15	15
Domestic	11	10	10
Commercial	6	6	6
Railway Traction	3	3	4
Public lighting, Water Works, Miscellaneous	5	4	4

Source: Southern Economist - Vol.19, P.16, December 1980.

A major portion of electricity (61 per cent) is consumed by industrial sector followed by agriculture (15 per cent) and domestic purposes (10 per cent), others including commercial, railway traction, public lighting, water works and miscellaneous consuming about 14 per cent of the total.

e. Consumption of Power - Statewise:

The details of Statewise per capita consumption by Household and Industrial sectors and the aggregate are furnished in Table 2.4.

Table 2.4

STATEWISE PER CAPITA POWER CONSUMPTION
1979-80

(In KWh)

S.No.	State/Union Territory	1978-79	1979-80	
		Household	Industrial	Aggregate
	States			
1.	Andhra Pradesh	10	57	95
2.	Assam	4	29	34
3.	Bihar	3	59	79
4.	Gujarat	21	168	240
5.	Haryana	18	115	250
6.	Himachal Pradesh	14	20	53
7.	Jammu and Kashmir	18	26	90
8.	Karnataka	18	132	153
9.	Kerala	14	86	104
10.	Madhya Pradesh	7	78	99
11.	Maharashtra	28	154	223
12.	Manipur	12	-	6
13.	Meghalaya	16	8	30
14.	Nagaland	38	1	24
15.	Orissa	4	91	116
16.	Punjab	29	177	328
17.	Rajsthan	6	60	104
18.	Sikkim	18	11	40

contd.

S.No.	State/Union Territory	1978-79	1979-80	
		Household	Industrial	Aggregate
19.	Tamil Nadu	16	108	181
20.	Tripura	7	2	15
21.	Uttar Pradesh	9	45	96
22.	West Bengal	16	89	113
	Union Territories			
23.	Andaman and Nicobar	13	10	49
24.	Arunachal Pradesh	5	2	13
25.	Chandigarh	87	145	326
26.	Dadra and Nagar Haudi	6	27	47
27.	Delhi	97	112	384
28.	Goa, Daman and Diu	22	118	207
29.	Lakshadueep	12	1	23
30.	Mizoram	4	-	9
31.	Pondicherry	23	106	224
	All India	14	87	134

Source: Commerce Annual Vol.147, P.339, 1980.

The average consumption of electricity for household purposes is 14 KWh. There are seventeen States in which the household consumption of electricity is more than the all India level. The average consumption of electricity for Industrial purposes in 87 KWh constituting nearly 65 per cent of the aggregate per capita consumption of electricity.

2. Related Studies:

a. Demand for Energy in India 1960 - 75:

The National Council of Applied Economic Research undertook a comprehensive programme of research covering the entire field of energy development in India in 1957 with a view to estimating the country's future requirements of coal, hydro - electricity, petroleum, and possible nuclear power, in the context of an expanding economy. This study presents estimates of demand for coal, hydro - electricity, petroleum, and nuclear power for quinquennial periods during 1960 - 75.

The hypothesis tested in this study is that energy consumption is not an end in itself in as much as it is a

necessary overhead of economic growth, its growth conditions and is, in turn, conditioned by the latter. In the initial stages of development, consumption of energy generally grows at a lower rate than GNP, and therefore, unit consumption declines with time. In India the income elasticity of total energy consumption was about 0.6 while that of primary energy was about 1.6.

The energy consumption function used in the study was of the form $E = E_p + E_c$, where E is total energy consumed; E_p = energy consumed as a factor in production (that is, energy used in industrial and transportation sectors); and E_c = energy consumed as a consumer good, mainly in domestic households and services. While E_p is more directly related to industrial growth, E_c is an indirect result of rising living standards brought about through more use of E_p. In India, only 30 per cent of the total energy is consumed in productive sectors, the rest being residential consumption. The proportion of E_p is expected to increase rapidly as economy progresses.

Starting with available information, the study makes an overall projection of total energy consumption relating these to the hypothesis of economic development. The sectoral analysis is broken up further into certain specific activities within that sector viz., Iron and Steel, Cement etc., in the industrial sector, and road and rail transport in transportation sector. The study had also analysed the breakdown of total energy by type of energy since electricity as a source of mechanical power is a very special and characteristic form of energy. Estimates of electricity demand were made separately for different sectors, and then substracted from the total energy demand to obtain requirements of coal and petroleum products. The demand for electricity is also broken down into thermal, hydro, and nuclear sources and an estimate made of installed capacities necessary to meet this demand.

The study concluded that the demand for electricity not only will grow more rapidly than that of other types of energy but also at a much higher rate than net national output.

b. Energy and Development:

Trehan et al (1979) had carried out a preliminary analysis of energy and development for less developed countries. Their work was part of a broader effort to provide analytical support for policy development in USAID energy assistance programmes. They estimated by means of quantitative linear regression analysis. The relationships between commercial energy production and consumption and economic and social development in 112 less developed countries. The results indicated that energy contributed heavily to socio - economic development in less developed countreis. The major findings of their analysis are:

1. GNP per capita is strongly related to commercial energy consumption.
2. Growth in GDP per capita is strongly related to growth rates in investment, employment and energy.
3. The Physical Quality of Life Index based on infant mortality, life expectancy and literacy is strongly

related to commercial energy consumption and to GDP per capita. This relationship between Physical Quality Life Index and energy consumption is relatively independent of the economic structure or geographic location of a country. The relationship of energy to GNP changes with the level of development of a country. A unit change in commercial energy consumption relates to approximately three times the change in GNP for advanced non-agricultrual less developed countries.

c. World Bank Research in Electric Power:

The World Bank's research study on electric power has been carried out by its staff, in 1972. Electric power has been a traditional area of emphasis in the World Bank's lending policy. Bank's research on power aids in improving investment decisions and pricing policy, strengthening instituions in the subsector, and providing a basis for policy guidance to borrowers.

Most of the research has focused on the development and application of economic engineering principles to both supply and demand uses. The principal areas of study in the Bank's research relate to pricing, investment planning and standards of supply, rural electrification, and review of the latest technology.

III. METHODOLOGY

The Methodology adopted in the current study on the 'Trend Analysis of Demand for Electricity in Tamil Nadu,' is described under the following heads:

1. Selection of the area.
2. Sources of data, and
3. Tools of Analysis.

1. Selection of the Area:

The investigator selected the State of Tamil Nadu for the study because Tamil Nadu is one of the industrially advanced States. Consumption of electricity in the State had almost always outstripped the generation, making her power position critical. In Tamil Nadu there has been a continuous increase in the excess demand for electricity during the period under consideration (1970 - 79) and the State had purchased electricity in all these years from surplus States. Hence, the position in Tamil Nadu was taken up for the indepth analysis.

2. Sources of Data:

Information on the extent of power generation from different sources and stations in Tamil Nadu, the contribution of different sectors to State income in Tamil Nadu, the consumption of electricity of different sectors in Tamil Nadu, and India were collected both from official and non-official sources.

a. Official Sources:

i. 'Power Engineer's Handbook published by Tamil Nadu Electricity Board Engineers' Association, 1976.

ii. India - A Reference Manual, Compiled by Ministry of Information and Broadcasting-Government of India, 1979.

iii. Tamil Nadu - An Economic Appraisal, published by Finance Department, Government of Tamil Nadu for the years 1970 - 79.

b. Non-Official Sources:

i. The Hindu - 'The Survey of Indian Industry' 1980 and 1981.

ii. The Surveys published in the periodicals of Commerce, Capital and The Indian Express (Vide Appendix I).

3. Tools of Analysis:

The percentage of sectoral consumption to total consumption, percentages of power generated from different sources and the proportion of deficit in power to total power generation were worked out. The model used in the study for estimating growth rates in the relevant variables and demand function was adopted from Kornai (1975) (Vide Appendices II and III)

a. For finding out the growth rates:

To find out the growth rates in the demand for electricity, and the contribution of agricultural and industrial sectors to Net State Domestic Product, an exponential trend line of the form

$Z_t = Z_o e^{\lambda t}$ was fitted, where

Z_t - Variable (demand for electricity, the share of agricultural sector and industrial sector to NSDP).

λ - growth rate

t - time

Z_o - initial co-efficient.

The results of this analysis furnished the growth rates in the relevant variables during the period under study.

a. For Estimating the Demand Function for Electricity:

Assuming a direct relation between the demand for electricity and the growth of agriculture and industry, the following function was fitted:

$D_E = CA^{\alpha} I^{1-\alpha}$ where

D_E - The demand for electricity.

A and I - The share of agricultural and industrial sectors to NSDP

C and α - Constants.

The value of α , the exponent of 'A' in terms of various growth rates was obtained. The above procedure was used for estimating the parameters of the demand function in preference to the multiple regression analysis for the following reasons:

i. It straightaway gives the various growth rates.

ii. The variables A and I are assumed to be an exponential function of time (ie) log A and log I are linearly related to t, time.
Kornai (1975) maintains that when a linear relation exists, or when there is collinearity between the variables, the multiple regression analysis cannot furnish an acceptable estimate.

The results of the study are discussed in the subsequent chapter on Results and Discussion.

IV. RESULTS AND DISCUSSION

The results of the analysis carried out are presented and discussed under the following heads:

1. Power Generation and Installed Capacity;
2. Sectorwise Electricity Consumption;
3. Excess Demand;
4. Determination of Growth Rates; and
5. Causes for the Growth in the Demand for Electricity.

1. Power Generation and Installed Capacity:

Tamil Nadu ranks third inpower generation and installed capacity. The details of installed capacity of different stations in Tamil Nadu are given in Table 4.1

Table 4.1

THE INSTALLED CAPACITY OF ELECTRICITY GENERATING STATIONS IN TAMIL NADU, 1970 - 71.

(In Megawatt)

Year	Electricity Board		Total
	Hydel	Thermal	
1970 - 71	1114 (57)	851 (43)	1965
1971 - 72	1224 (59)	851 (41)	2075
1972 - 73	1224 (56)	947 (44)	2171
1973-74	1224 (54)	1030 (46)	2254
1974 - 75	1224 (54)	1030 (46)	2254
1975 - 76	1224 (52)	1140 (48)	2364
1976 - 77	1224 (52)	1140 (48)	2364
1977 - 78	1284 (53)	1140 (47)	2424
1978 - 79	1369 (54)	1140 (46)	2509

Source: Tamil Nadu - "An Economic Appraisal " - Published by Finance Department - Government of Tamil Nadu - P-52 1979.

Foot Note: (Figures in parentheses indicate percentages to total)

The installed capacity in Tamil Nadu had continuously increased during 1970 - 79. The ratio of installed capacity between hydel and thermal sources was 57:43 in 1970 - 71 and it was transformed to 54:46 in 1978 - 79. The relative weight of hydel stations decreased over a period of time and the State began to diversify into other sources.

The details of electricity generated in different stations in Tamil Nadu are furnished in Table 4.2.

Table 4.2

ELECTRICITY GENERATION OF DIFFERENT STATIONS IN TAMIL NADU

1970 - 79

(in m.u.)

Year	Hydel	Thermal	Total
1970 - 71	3043 (84.5)	557 (15.5)	3600
1971 - 72	3745 (85.8)	618 (14.2)	4363
1972 - 73	4144 (81.6)	932 (13.4)	5076
1973 - 74	3702 (76.0)	1171 (24.0)	4873
1974 -75	3827 (75.4)	1249 (24.6)	5076
1975 - 76	4405 (77.0)	1317 (23.0)	5722
1976 - 77	2753 (55.9)	2176 (44.2)	4929
1977 - 78	3768 (67.1)	1852 (33.0)	5620
1978 - 79	4525 (68.5)	2082 (31.5)	6607

Source: Tamil Nadu - " An Economic Appraisal" Published by Finance Department - Government of Tamil Nadu - 1979 P-126 (Figures in parenthesis indicate percentages to table).

Power generation from hydel sources had continuously increased except during 1873 - 74 and 1976 - 77. Power generation from thermal stations was also increasing except during 1977 - 78. In seventies the total power generation had nearly doubled (from 3600 m.u. to 6607 m.u.)

2. Sectorwise Electricity Consumption:

Details of consumption of electricity by different sectors in Tamil Nadu in absolute and monetary terms during 1970 - 79 are given in Tables 4.3 and 4.4.

Table 4.3

ELECTRICAL ENERGY SALES BY QUALITY BY SECTORWISE IN TAMIL NADU DURING 1970-79 (in m.u.)

Item	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
Domestic	247(4.9)	273(5.1)	276(5.1)	316(5.9)	395(6.7)	469(7.5)	496(7.7)	555(7.4)	627(7.7)
Commercial	332(6.6)	368(6.8)	414(7.7)	286(5.3)	381(6.8)	401(6.4)	437(6.7)	482(6.4)	533(6.6)
Industrial	2474(48.9)	2646(49.2)	2325(43.3)	2334(43.6)	2402(42.6)	2938(46.9)	3107(47.8)	3539(47.3)	4200(51.8)
Public Lighting	58(1.2)	71(1.3)	66(1.2)	67(1.25)	79(1.4)	83(1.3)	74(1.1)	76(1.0)	81(1.0)
Traction including Railways.	81(1.6)	84(1.6)	97(1.8)	69(1.3)	39(0.7)	54(0.8)	97(1.5)	208(2.8)	110(1.4)
Irrigation	1241(24.5)	1269(23.6)	1430(26.6)	1576(29.4)	1847(32.7)	1675(26.7)	1697(26.2)	786(23.9)	2104(26.0
Miscellaneous	624(12.3)	639(11.9)	763(14.2)	717(13.4)	502(8.9)	648(10.3)	583(9.0)	839(11.2)	452(5.6
Total	5057(100)	5380(100)	5371(100)	5355(100)	5645(100)	6268(100)	6485(100)	7485(100)	8107(100

Source: Tamil Nadu - " An Economic Appraisal - Published by Finance Department - Government of Tamil Nadu - 1979 P-12 (Figures in parentheses indicate percentages to total)

Table 4.4

ELECTRICAL ENERGY SALES BY VALUE BY SECTORWISE IN TAMIL NADU DURING 1970-79 (In lakhs of Ruppes)

Item	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
Domestic	787(13.1)	884(13.6)	1056(13.61)	1211(16.0)	1680(13.8)	1996(12.6)	2049(11.4)	2227(11.7)	2394(12.
Commercial	828(13.8)	939(14.4)	1162(15.0)	1176(15.6)	1588(13.0)	1897(12.0)	1945(10.8)	1938(10.2)	2467(12
Industrial	2205(36.8)	2342(36.0)	2464(31.8)	2629(34.8)	3764(30.9)	4758(30.0)	4732(26.4)	5156(27.2)	8438(42
Public Lighting	184(3.1)	240(3.7)	238(3.1)	253(3.3)	285(2.3)	297(1.9)	264(1.5)	266(1.4)	272(1.
Traction including Raiways.	90(1.5)	96(1.5)	126(1.6)	89(1.2)	31(0.3)	54(0.3)	147(0.8)	141(0.7)	188(0.
Irrigagion	1293(21.6)	1397(20.1)	1825(23.5)	2017(26.7)	2473(20.3)	2836(17.9)	3496(19.5)	3567(18.8)	3531(17
Miscellaneous	606(10.1)	628(9.7)	888(11.4)	190(2.5)	2365(19.4)	4005(25.3)	5323(29.6)	5667(29.9)	2743(13.
Total	5993(100)	6506(100)	7759(100)	8942(100)	12186(100)	15843(100)	17956(100)	18962(100)	20033(10

Source : Tamil Nadu - An Economic Appraisal - Published by Finance Department - Government of Tamil Nadu, 1979, P.12

(Figures in parentheses indicate percentages to total)

The industrial sector is the major consuming sector and the consumption pattern has remained more or less similar over the decade. The percentage share of the industrial sector in electricity consumption had risen gradually from 49 per cent in 1970 - 71 to 51.8 per cent in 1978 - 79. On the same lines the consumption of the agricultural sector increased from 24 per cent in 1970 - 71 to 26 per cent in 1978 - 79. More than three fourths (77.8 per cent) of the electricity that is generated is used up by the agricultural and industrial sectors in Tamil Nadu.

The trend of electricity consumption in the domestic and commercial sectors is smooth. It is on the higher side in the case of domestic sector. The consumption of electricity by the domestic sector is slightly and steadily increasing. There is no increase in electricity consumed by the commercial sector. In the case of traction including railways the consumption of electricity has doubled during 1977 - 78 as compared to other years. Public lighting consumed just one per cent of total electricity used in the State.

In absolute terms demand for electricity has increased particularly in industrial and agricultural sectors. The total power consumption has increased from 5057 m.u. in 1970 - 71 to 8107 m.u. indicating nearly 60 per cent increase.

3 Excess Demand:

The amount of electricity generated in the State had always been inadequate to meet her requirements. Consequently, the excess demand had to be met by other means. The State had purchased electricity from the neighbouring States in lean months to cope up with the demand. The deficit in power availability is equated with the amount of electricity which the State had to purchase from the neighbouring States of Kerala and Karnataka. The proportion which this deficit bears to the total power consumption or requirement in the State indicates the magnitude of the problem of power shortage in the State. Table 4.5 gives the estimate of deficit in power supply in relation to requirement over the period 1970 - 79.

Table 4.5

POWER REQUIREMENT AND DEFICIT IN POWER SUPPLY IN TAMIL NADU

1970 - 79

(in m.u.)

Year	Power Requirement.	Deficit	Deficit as a proportion of the power requirement
1970 - 71	5057	1058	21
1971 - 72	5380	523	9
1972 - 73	5371	404	8
1973 - 74	5385	432	8
1974 - 75	5645	471	8
1975 - 76	6268	356	6
1976 - 77	6485	576	9
1977 - 78	7485	1201	16
1978 - 79	8107	1774	22

Source: Tamil Nadu - An Economic Appraisal - Published by Finance Department - Government of Tamil Nadu P. 127 - 1979.

The ratio of deficit in power supply to the requirement was 21 per cent in 1970 - 71. The problem of shortage began to ease from 1971 - 72 onwards. This trend was reversed in 1976-77 when the gap between availability and requirement again widened year after year making the problem again as big as it was in the beginning. In 1978 - 79 about one fifth of the State's requirement had to be met from the purchases which the State contracted from surplus neighbours. The deficit in power supply persisted and widened between 1976 - 79 in spite of the steady increases that had taken place in the quantity of power generated by the electricity projects under the control of electricity Board and the steady increase in the purchase of power from the Thermal Station at Neyveli under Central Government purview.

4. Determination of Growth Rates:

Compound growth rates of the two major sectors of the State's economy namely agriculture and industry were estimated and these rates were set against the compound growth rate in the demand for electricity by these two sectors together and the compound growth

rate in the overall demand for electricity. The growth rates were eventually used to assess the causal relationship between the growth of these sectors and the growth in the demand for electricity.

The empirical results of the growth rate functions fitted to the four key variables of State's economy's demand for electricity, demand for electricity in the agricultural and industrial sectors together, NSDP derived from agricultural and industrial sectors are presented in Table (4.6)

Table 4.6

COMPOUND GROWTH RATE FUNCTIONS

S.No.	Particular	Initial Co-efficient	Exponent	Co-efficient of determination
1.	State Economy's demand for electricity $D_E$le	2785	.15	.98
2.	Demand for Electricity in agricultural and industrial sectors D_E (A+I)	3262	.061	.92
3.	NSDP from Agriculture 'A'	92510	.011	.88
4.	NSDP from Industry'I'	43990	.021	.81

The growth equations obtained were:

$D_E = 2785\ e^{.15t}$

$B_E\ (A+I) = 3262\ e^{.11t}$

$A = 92510\ e^{.061t}$

$I = 43990\ e^{.021t}$

The growth equations had very high co-efficients of determination ranging from .81 to .98 indicating that the form of the function used was the best.

The compound growth rate in the overall demand for electricity was 15 per cent per annum. In the two specific sectors of agriculture and industry the consumption of electricity increased at the rate of 6 per cent per annum. The residual increase in the rate of electricity consumption in the state was explained by the increased use of electricity in the other sectors domestic, commercial, railways and public lighting.

During the period 1970 - 79 the Net State Domestic Product derived from agriculture had grown at the rate of 1.1 per cent per annum and the NSDP derived from industry had grown at the rate of 2.1 per cent per annum. The consumption of electricity in these sectors had increased at rates much faster than the growth rate of income from agricultural and

industrial sectors. The period under study is associated with the break through in agricultural production. More and more, agriculture began to acquire a commercial character with the prospects, of better yields, thanks to green revolution. Farmers resorted to intensive cultivation in a larger degree, The crop patterns were diversified and a given unit of land was used to produce more crops and in larger amounts. With all these, methods of irrigation were modernised. Other agricultural operations, plant protection, threshing etc., were more and more done with the assistance of electricity operated devices. With the industrialisation in the State the application of electrical energy had also increased. Traditional industries were modernised involving the use of electricity as in the case of substitution of handlooms by power looms in the handloom sector. The rate of growth in the consumption of electricity by the two sectors taken together with the expected the rate of growth of incomes from them underscored the structural transformation taking place within those sectors. It was the structural transformation within the sectors which explains the discrepancy in the respective growth rates.

The projections of demand for electricity in the State of Tamil Nadu were worked out for the period 1970 - 90, using the equation obtained for the over all demand for electricity:

$$D_E = 2785_e^{.15t}$$

Table (4.7) gives details of the estimated demand for electricity and Figure 1 illustrates the trend.

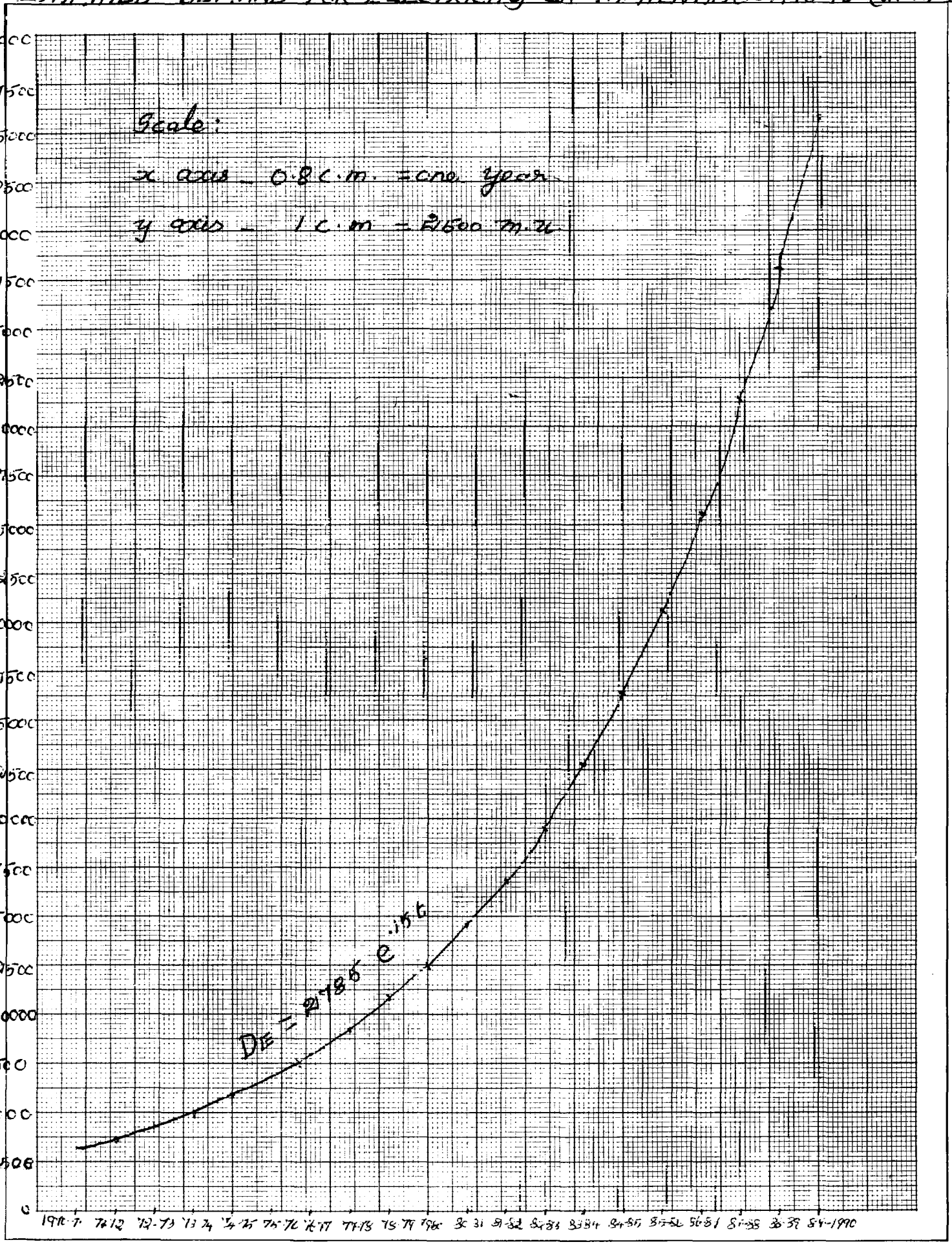
Table 4.7

ESTIMATED DEMAND FOR ELECTRICITY IN TAMIL NADU - 1970-90

(in m.u,)

Year	Power Requirement
1970 - 71	3230
1971 - 72	3731
1972 - 73	4367
1973 - 74	5074
1974 - 75	5896
1975 - 76	6849
1976 - 77	7958
1977 - 78	9246
1978 - 79	10742
1979 - 80	12480
1980 - 81	14670
1981 - 82	16840
1982 - 83	19570
1983 - 84	22740
1984 - 85	26420
1985 - 86	30700
1986 - 87	35670
1987 - 88	41440
1988 - 89	48150
1989 - 90	55940

ESTIMATED DEMAND FOR ELECTRICITY IN TAMILNADU 1970-90 (in M.W.)



The demand for electricity is likely to go upto 55940 m.u. in 1990 assuming that the growth rate in the State economy will remain constant. This increase in the demand for electricity will have to be met from new power sources since the State has exhausted its hydel potential. The alternative sources of electrical energy - thermal, nuclear remains to be exploited. The capacity for power generation in the State remained at 6607 m.u. in 1978 - 79. If the requirement of the state in regard to power in 1990 are to be met, the State will have to plan for fuller utilisation of the existing capacity and also set up new power generating stations. Power generation being a long gestation industry, the State will have to plan considerably ahead of time. The National Power Grid System will perhaps take care of the increased power needs of the State.

5. Causes for the Growth in the Demand for Electricity:

The causal relationship between demand for electricity and the income derived from agriculture and industry was ascertained using a model. For this purpose, a restricted exponential demand function of the form.

$D_E = C A^{\alpha} I^{1-\alpha}$ where

D_E = Electricity consumed by the agricultural and industrial sectors.

C = Initial co-efficient

A = State Income derived from Agriculture.

I = State Income derived from Industry.

$\alpha, 1-\alpha$ = Constants.

was fitted to the data. The sum of the exponents of A and I was assumed to equal unity, implying that the changes in the volume of agricultural and industrial production fully accounted for the changes in the demand for electricity in these two sectors. The exponent of A, α stood for the elasticity of demand for electricity with respect to agricultural output. The exponent of I, $1 - \alpha$ Characterised the elasticity of demand for electricity with respect to industrial output.

The values of the parameters in the function were obtained from the growth rates discussed earlier. This method was used in preference to the multiple regression analysis as it avoided the problem of multi - collinearity inherent in the variation of the variables over time (Kornai 1975).

The empirical results of the demand function for elactricity in the two sectors of agriculture and industry in the State are stated below:

$$D_E = 2.005\ A^{-4.4}\ I^{5.4}\quad R^2 = .92$$

The Co-efficient of determination of the demand equation for electricity was high at .92 The elasticity of demand for electricity with respect to agricultural output was negative at 4.4. The elasticity of demand for electricity with respect to industrial output was positive and the magnitude of the elasticity was 5.4. These results satisfied the restrictive condition imposed on the equation earlier.

A large number of factors influenced agricultural production. The cropping pattern, size of holdings, extent of irrigation, soil fertility, availability and dissemenation of agricultural methods, and use of fertilizers were some of the factors that influence the agricultural production in the State besides the use of electrical energy for the purpose of irrigation and other agricultural operations. The application of electricity in farming is one among a whole complex of factors which act and react upon one another in deciding agricultural output. The negative elasticity of demand for electricity obtained with reference to agricultural output indicates thus that agricultural output is by and large dependent on the factors enumerated above rather than on the use of electricity alone.

Industry on the other hand is a predominent user of electricity. Electricity is one of the major inputs as well as the major form of energy used in the industrial sector. The high positive co-efficient obtained for demand for electricity with respect to industrial output thus needs no explanation. A unit increase in industrial output can be expected to increase demand for electricity by 5.4 units.

The main findings and conclusions of the study are summarised in the next Chapter on "Summary and Conclusion".

V. SUMMARY AND CONCLUSION

The current study on the "Demand for Electricity in Tamil Nadu" was an attempt to find out the causes for the growth in the demand for electricity in terms of agricultural and industrial growth during 1970 - 79. The data collected from the official and non-official sources was analysed by applying exponential trend functions and the major findings that emerged from the analysis were:

Power Generation and Installed Capacity:

1. The ratio of installed capacity between hydel and thermal sources was transformed from 57:43 in 1970 - 71 to 54:46 in 1978-79.
2. Power generation from hydel sources has decreased from 85 per cent in 1970 - 71 to 69 per cent in 1978 - 79 and the corresponding increase in power generation from thermal stations was 15 per cent in 1970 - 71 and 31 per cent in 1978 - 79.

3. The quantum of power generated nearly doubled (3600m.u. in 1970 - 71 and 6607 m.u. in 1978 - 79) during the period.

Electricity Consumption:

4. The consumption of electricity by the industrial sector has increased from 49 per cent of the total consumption in 1970 - 71 to 51 per cent in 1978 - 79.
5. The consumption of electricity by the agricultural sector has increased from 24 to 26 per cent during the period 1970 - 79.
6. Seventy seven per cent (i.e) about three fourths of the total electricity generated was consumed by the agricultural and industrial sectors.
7. One per cent of electricity generated was consumed for public lighting purposes in all the years.

8. There were no wide fluctuations in the consumption of electricity by the domestic sector, commercial sector and traction including railways. It was nearly 23 per cent in all the years.

9. The total power consumption has increased from 5057 m.u. in 1970-71 to 8107 m.u. in 1978-79, nearly 60 per cent increase.

Excess Demand:

10. The ratio of deficit in power supply to the requirement of power was 21 per cent in 1970 - 71. The deficit which was getting narrowed during 1972 - 77 again widened in 1978 - 79 and became as high as 22 per cent in the Beginning.

Growth Rates:

11. The overall State economy's demand for electricity has increased at a compound growth rate of 15 per cent per annum.

12. The growth rate of demand for electricity by the agricultural and industrial sectors together was 6 per cent.

13. The State NDP derived from agricultural sector has grown at a rate of 1.1 per cent per annum.

14. The State NDP derived from industrial sector has grown at a compound rate of 2.1 per cent per annum.

15. The projected demand for electricity in the State in 1990 will be 55940 m.u.

Demand Function:

16. The impact of industrial growth on the demand for electricity was very high (5.4 times per unit increase in industrial output).
17. The growth of agricultural output has negative relation with the demand for electricity.

Areas for Further Research:

1. Studies on the demand for electricity statewise are indicated as such inter-area studies would be helpful in locating imbalances in generation and consumption of power and in suggesting suitable methods to overcome these imbalances.

2. The elasticity of demand for electricity with respect to agricultural output was negative with a high coefficient. The factors responsible for this type of causal relationship may well constitute another fertile area of research.

Conclusion:

The findings of the study indicate that the power position in the State will become critical in the day to come in the context of the deficit in power supply that exists already and the demand for electricity that tends to increase at an increasing rate, in the eighties and nineties. The State Government should think of exploiting the thermal and nuclear sources of energy to meet the challenges of increased demand for power and self-reliance.

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APPENDIX I

The State Economy's demand for electricity, the demand for electricity by agricultural and industrial sectors and the NSDP derived from Agricultural and Industrial Sectors in Tamil Nadu - 1970-79

Year	Overall Demand for Electricity in m.u. Power generated + Electricity purchased.	Demand for Electricity by Agricultural & Industrial Sectors in m.u.	NSDP (Rs. in lakhs)	
			Agriculture	Industry
1970 - 71	3498	3715	94983	45871
1971 - 72	3719	3915	101524	46574
1972 - 73	4289	3725	99222	48059
1973 - 74	4646	3910	108643	46556
1974 - 75	6337	4249	74410	47448
1975 - 76	7594	4613	95720	47520
1976 - 77	8228	4708	89902	49683
1977 - 78	8723	5325	105379	51457
1978 - 79	11969	6304	118644	56810

Source: Tamil Nadu - An Economic Appraisal - Published by Finance Department - Government of Tamil Nadu - P. 99 1979.

APPENDIX II

Determination of Growth Rates:

Since there is no constant growth increment in the relevant variables an exponential trend line is fitted.

$Z_t = Z_o \, e^{\lambda t}$ where

Z_t = variable

λ = growth rate

t = time

In logarithmic form

$$\text{Log } Z_t = \text{Log } Zo + \lambda t \ \log e$$

This is of the form

$Y = a + b\,x$ where

$y = \text{Log } Z_t$

$a = \text{Log } Z_o$

$b = \lambda \log e$

$x = t$

The normal equations used to find out the least square line in logarithmic form are:

$$\Sigma \log Z = N \log Z_o + \lambda \log e \Sigma t$$

$$\Sigma (t \log Z) = \text{Log } Z_o \Sigma t + \lambda \log e \Sigma t^2$$

APPENDIX III

A) ESTIMATION OF THE PARAMETERS OF THE DEMAND FUNCTION:

A restricated exponential demand function of the form:

$D_E = C\ A^{\alpha}\ I^{\ 1-\alpha}$ Where

B_E = State Economy's demand for electricity.

A = NSDP derived from agriculture

I = NSDP derived from industry.

α, C, $1-\alpha$ = Constants

was fitted.

The value of α in terms of various growth rates is given by the formula

$$\alpha = \frac{\lambda - \beta}{\gamma - \beta}$$ where

λ = Growth rate with demand for electricity by agricultural and industrial sectors.

β = Growth rate of industrial sector

γ = Growth rate of Agricultural sector (Kornai 1975)

The value of 'C' is obtained from the equation given below:

$$\frac{D}{I} = C \left(\frac{A}{I}\right)^{\alpha}$$

$$\text{Log} \left(\frac{D}{I}\right) = \text{Log } C + \alpha \log \left(\frac{A}{I}\right)$$

$$\Sigma (\log D - \log I) = \text{Log } C + \alpha (\text{Log } A - \text{Log } I)$$

From the normal equations of regression analysis, given the value of α the value of C is obtained.

b. Estimation of R^2

Co-efficient of determination (Kaplan and Norman – 1975). The exactness of the fitted functions was found from the values of Co-efficient of determination - R^2. It is calculated by the formula

$$R = 1 - \left(\frac{sy}{y\sigma}\right)^2 \text{ where}$$

sy = Standard error of estimate

$$= \sqrt{\frac{\Sigma (y - YF)^2}{N}} \quad \text{Where}$$

Y = Actual value

YF = Fitted Values

N = Number of observations

σ y = Standard deviation.