ELECTRICITY DEMAND

IN

DARWIN (1990 - 1994)

A dissertation submitted to the Graduate School of Business

Northern Territory University

by

THANH TANG

In partial fulfilment of the requirements for
the Graduate Diploma in Business Studies

Supervisor : Dr. SAJID ANWAR

JANUARY 1996

Certification of Research Originality

I certify that this dissertation is entirely my own work and has not been submitted previously to fulfil the requirements of an award at any University or Institute of Higher Education. To the best of my knowledge and belief, this dissertation contains no material previously published or written by another person, except when due reference is made in the text of the dissertation.

THANH TANG

Date : 22 January 1996

This dissertation is submitted in partial fulfilment for the Graduate Diploma in Business Studies (BGDBS) in the Graduate School of Business, Northern Territory University, Darwin, Australia.

Acknowledgments

I wish to express my special appreciation to Dr. Sajid Anwar who provided helpful reviews and kind advice during the preparation of this dissertation.

CONTENTS

ABSTRACT

The purpose of this research project is to identify the most relevant independent factors affecting the annual growth in the demand for electricity in Darwin over a period commencing 1990 to 1994. The three econometric equations to be estimated are the annual energy consumption equations (GWh) for both domestic and commercial sectors and the maximum demand equation (MW). The linear regression analysis is used to estimate the three econometric equations. The location considered in the study is a geographical area covering the cities of Darwin and Palmerston.

The independent variables that have been considered suitable to outline the variation of annual energy consumption in both the domestic and commercial sectors are the Darwin population, number of electricity consumers, tariff structure, average annual earnings, gross state product per capita, level of housing finance commitment and the prevailing weather patterns.

It is found that factors such as number of domestic consumers and average annual earnings are suitable to explain variations in the domestic energy consumption estimate. However, at the selected 5% level of significance, only the number of domestic consumers stands as the most suitable independent variable to estimate the annual domestic energy consumption equation.

Similar result is found in the case of estimating the commercial energy consumption equation, the commercial consumers independent variable is best used to predict variations in the annual commercial energy consumption.

The domestic energy consumption and the commercial energy consumption independent variables are found to provide the most appropriate means in estimating the maximum demand equation.

The forecast of these econometric equations will assist the Supply Authority to plan ahead for future Electricity Generation, Transmission and Distribution expansion or augmentation. It will also provide a means to assess future long-term fuel contracts as well as to evaluate appropriate capital investment requirements for domestic and commercial consumers.

CHAPTER 1

INTRODUCTION

Electrical equipment is rated in watts, W or MW (1MW = 1,000,000W), ie. a measure of the power demand drawn when equipment is connected to power supply source. All the electrical equipment installed by consumers is not switched on at the one time nor do the load levels remain constant, the actual power generated by the Supply Authority is less than the total of all installed equipment ratings and also varies with time. The actual maximum power drawn by consumers is called the peak electricity demand or load.

Electrical energy consumption, expressed in kilowatt hour (kWh) or gigawatt hour (1GWh = 1,000,000,000 kWh), depends on the electrical power rating and the consumption period. The important characteristic which distinguishes electricity from other forms of energy is that it is effectively impossible to store in large quantities. Consequently, the rate at which electricity is being consumed at any given time, by the various groups of consumers connected to the system, must at least be equalled to the rate at which the Power Station is able to match the demand. Fundamental to The Electricity Supply Authority, therefore, is the question of how best to match estimated future demands for supply while at the same time avoiding shortages or over-investment in generation capacity. A further important factor is the necessity to provide sufficient flexibility in Power Station planning and construction programs to enable them to be adjusted to changing demand growth.

The availability of electricity is closely linked to the continuing development of society as we know it. Electricity is no longer considered a privilege but a necessity. However, providing the infrastructure for generating and delivering electricity to customers is a major capital expense for any Government or Supply Authority, particularly as the infrastructure cost increases substantially when providing electricity to small population of under 100,000 such as in Darwin. The typical cost for electricity infrastructure in the NT is in the order of $3000 for each kW of connected load.

The source of electricity supply for Darwin is from the Channel Island Power Station which is about 35km by road from the Palmerston Central Business District. Construction of the Power Station commenced in 1982 at the cost of around $230 million. The station was commissioned in 1988 and now is capable of satisfying a maximum demand of 230MW. Demand for electricity in Darwin has been steadily increasing over a period of 20 years from 8MW to 162MW (1963 - 1994).

A previous load forecast report published by the Northern Territory Power And Water Authority, Planning Section has looked at the energy generated at the Power Station (See reports Sep 1985 and July 1990) and the load forecast to include for the connection of Katherine (Darwin/Katherine in report March 1993).

My research is an attempt to explain the variations in annual domestic energy consumption, commercial energy consumption and maximum demand by examining the effects of each of the individual factors such as population, number of consumers, tariffs, average annual earnings, gross state product per capita, annual housing finance commitment and weather conditions.

Identifying appropriate individual independent variables is the first step in producing the econometric equation. Through the use of linear regression analysis based on the ordinary least square technique, three econometric equations are developed to estimate the annual domestic energy consumption, commercial energy consumption and maximum demand for electricity.

It is found that the number of domestic consumers stands as the most suitable independent variable to estimate the annual domestic energy consumption equation at the selected 5% level of significance. Similar result is found in the case of estimating the commercial energy consumption equation, the commercial consumers independent variable is best used to predict variations in the annual commercial energy consumption. The domestic energy consumption and the commercial energy consumption independent variables are found to provide the most appropriate means in estimating the maximum demand equation.

Forecasts based on these findings will assist the Supply Authority in :

- Estimating short term or long term electricity generation, transmission and distribution expansion requirements;
- Preparing plant retirement and augmentation schedules;
- Assessing long term fuel contract requirements with suppliers;
- Budgeting appropriate capital investment requirements to meet domestic and commercial customers' demands.

The plan of the research is as follows. In the next chapter review of related literature over the last ten years are explained in more details. This is followed by discussion of methodology, data selection and the specification of the three model equation in general terms in Chapter 3. Chapter 4 contains the findings of the analysis. Chapter 5 provides the summary and conclusion of the research.

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

As each electricity Supply Authority prepares its own forecasts by using a variety of historical and collected data with different modelling techniques, the overall results may not be comparable, as their methodologies may assign different values and weighting factors to each model such as economic climate and outlook, changes in price of competing energy sources, patterns of users' energy consumption, and other recent demand trends.
Other electricity Supply Authorities in the Southern States consider heating in winter is an important factor influencing their power consumption and peak demand whereas it is an inappropriate factor to be considered in Darwin.

Over the last ten years, a number of reports related to Darwin load growth have been prepared by the Planning Section in the Power And Water Authority (PAWA) as follows :

(i) Darwin Load Forecast Report - Sep 1985 :

The data analysed for this study covers the period 1978 to 1984. The resultant forecasts are provided in the form of energy generated (a measurement at the power station generator terminals), energy sent out (a measurement of energy available for distribution after auxiliary losses at the power station) and maximum demand. Independent variables used are Darwin population, monthly average temperature, long term mean relative humidity index and commercial tariff. The methodology used in the forecasting model is based on regression equations estimated by the ordinary " least squares technique " and has been selected according to the statistical significance of the variables in the overall equation. The study concentrates on aspects of forecasting factors that influence the electricity generation capability of the Power Station. Different classifications of consumers and how they consume the electricity are not looked at.

(ii) Darwin Load Forecast - July 1990 :

The technique employed is identical to that used for the Darwin load forecast report in 1985. Two econometric equations - sent out energy and maximum demand outcomes - are referred to as dependent variables. The data analysis is based on an expanded set of data from 1979 to 1988. The number of independent variables used are increased from four in 1985 study to six in 1990 study. The NT population independent variable is replaced by the total number of consumers connected. New independent variables used are average weekly earnings and energy delivered in a maximum demand equation. The wages term acts as a general term in these equations, capturing not only the effect of earnings on demands but reflecting movements in prices generally. The commercial consumers variable is not examined in relation to the commercial energy consumption.

(iii) Darwin / Katherine System Load Forecast - March 1993 :

In the report, the Darwin population census is not used as one of the independent variables in the econometric equation for estimating the maximum demand for electricity. The reason is that the latest Darwin population figure is not readily available from the census result published by the Australian Bureau of Statistics (ABS) which took place on June 30, 1992. This report utilises, instead the total consumption both domestic and commercial in the Darwin and Katherine areas and does not attempt to derive the maximum demand equation nor the energy consumption of domestic and commercial consumers for the Darwin area alone.

My research project is an attempt to provide a means to estimate the annual energy consumption of a number of domestic or commercial areas in Darwin over a period commencing 1990 to 1994. Also, this study explores the relationships between the domestic and commercial annual energy consumption in the maximum demand equation.

CHAPTER 3

METHODOLOGY and PROCEDURES

Linear regression is probably the most widely used statistical tool. The analysis is more sophisticated than the trend approach and offers greater flexibility in forecasting exercises. Regression analysis establishes relationships between variables using historical data and uses these relationships to develop a forecasting equation. Econometric equations are estimated by the ordinary least square technique satisfying a preset level of statistical significance of the variables and the goodness of fit of the overall equation.

This study assesses the response of annual electricity consumption and maximum demand in relation to external factors (independent variables), and the relative size of, and movement of these variables to the 5% level of significance. Independent variables employed in the each of the econometric equations are selected from a simple linear regression analysis. Each independent variable, in turn, is correlated with the dependent variable to determine the presence of, or lack of, linear-correlation. Exact relationships between independent variable and dependent variable do not exist in regression analysis. Therefore the dependent variable may actually be part of a cause-and-effect relationship, or it may simply be "correlated" with one or more independent variables without any evidence of a cause-and-effect relationship.

The linear regression method has been chosen for this study because of its relatively simple process, greater flexibility and its ability to provide a rigorous framework for policy evaluation.

The following independent variable information are examined to establish a table of data required for the regression analysis :

1. Darwin Population :

The information for the historical population data is provided by the Australian Bureau of Statistics (ABS) and is published in recent census reports. The result represents the numbers of people in each statistical division on the night of the census. Yet to be added or subtracted are the number of residents interstate or overseas at the time and the number of people visiting Darwin from interstate, intrastate and overseas at the time of the census.

In between major census exercises, the ABS publishes Estimated Resident Population (ERP) data on an annual basis. These estimates use the census figures as a base reference and, on a regular basis such data as the number of persons receiving child endowment payments, dwelling statistics, school enrolments, births and deaths are included. The Estimated Resident Population data does not truly reflect the level of Electricity Consumption compared to the number of Electricity Consumers. Therefore it is not selected as a suitable factor in the study.

2. Number of Electricity Consumers :

The number of Electricity Consumers for domestic and commercial usage is readily available from the Power and Water Authority Customer Information Services (CIS) computer system. They are chosen as independent variables in place of the Darwin population variable. Because this information is well documented annually and each consumer can be identified as either domestic or commercial. Hence they provide more information which can be utilised for prediction of either a domestic or commercial energy consumption and peak power demand. It is expected that the number of Electricity Consumers, domestic and commercial, has a positive relationship with the estimated annual energy consumption and therefore, the increase in the number of consumers causes the energy consumption to increase.

3. <u>Tariff structure :</u>

Presently within the Power and Water Authority, there are Domestic and Commercial or General Purpose tariffs for different types of consumers. A Time of Day tariff has also been available to large Commercial customers since July 1986. This energy tariff is designed to encourage eligible consumers to increase energy consumption during periods of low-peak demand and to discourage consumption during periods of peak demand. However the number of commercial customers eligible to Time of Day tariff is insignificant. The tariff structure is available from the Customer Services Section of the Power And Water Authority. It is believed that the tariff variable is inversely proportional to the annual energy consumption and that the higher tariff rate reduces the energy consumption.

4. <u>Average Annual Earnings :</u>

Average annual earnings are thought significant in forecasting domestic energy consumption in that they reflect disposable income. They are in fact, the only readily available proxy for disposable income. While nominal dollar average earnings have not necessarily increased to the same level as Consumer Purchasing Index (CPI), the trend over the last 5 years has been for disposable income to increase. This has been mainly due to a decline in marginal taxation. The effect of this has been to increase the spending power available to income earners without any increase in " the wages bill " to employers. Therefore without the general price increases usually associated with an increase in average annual earnings. Average annual earnings figures are calculated from average weekly income (source : Australian Bureau of Statistics publication " Northern Territory in Focus ") times a factor of 52. It is expected that average annual earnings is directly proportional to annual energy consumption.

5. <u>Gross State Product per Capita :</u>

Gross State Product per Capita is a measure of economic production which is used in comparing the economic activity at the State or Territory level. The NT economy is different from that of the other Australian States and Territories due to historical and natural factors. These differences lie in a relatively large public sector, a rapidly expanding mining sector and a relatively small and narrow manufacturing sector. This data is obtained from the Australian Bureau of Statistics publication " Northern Territory in Focus ". The Gross State Product per Capita data is believed to have a positive effect on both domestic and commercial Electricity Consumption levels.

6. Housing Finance Commitment :

The Housing Finance Commitment is the amount of money people spend annually on purchasing property which is either to be constructed or is already established. This variable can be interpreted as a measure of the level of wealth that people of Darwin spend on their homes. The data is obtained from the Australian Bureau of Statistics publication " Northern Territory in Focus ". The Housing Finance Commitment variable is expected to have positive effect on both the domestic and commercial power consumption levels.

7. Weather conditions :

The only records of the mean levels of Temperature for the Darwin Area and the Relative Humidity data are available in publication from the Darwin Bureau of Meteorology. The differences captured in these records are insignificant for the examination of the effect of weather conditions on annual Power Consumption and Peak Demand. Therefore, the weather condition indexes are eliminated from the collection of data table.

DARWIN - DATA COLLECTION

Description / Unit	**1990**	**1991**	**1992**	**1993**	**1994**
Domestic Consumers	26,154	26,653	28,305	29,346	30,478
Commercial Consumers	4,290	4,372	4,302	4,790	4,807
Total Consumers	30,444	31,025	32,607	34,136	35,285
Domestic Tariff (cents/KWh)	11.03	11.03	11.39	11.76	12.03
Commercial Tariff (cents/KWh)	14.58	14.58	15.05	15.54	15.89
Average Annual Earnings of Adult ($)	31,736	33,015	34,918	35,173	35,422
Gross State Product per Capita ($)	21,191	24,562	26,731	25,081	24,908
Housing Finance Commitment ($ million)	107.0	91.7	120.8	165.0	303.0
Domestic Energy Consumption (MWh)	179,273	184,944	188,315	199,437	202,436
Commercial Energy Consumption (MWh)	452,376	469,903	464,550	507,374	521,304
Maximum Demand (MW)	126.0	133.7	149.0	157.3	162.0

The analysis procedure includes three econometric models which are estimated as follows :

1. Domestic Energy Consumption equation :

The equation for the Consumption of Domestic Energy measured in MWh is to be generated from regression analysis. The suitable independent variables to be examined in annual Domestic Energy Consumption equation are Domestic Consumers, Domestic Tariff, Average Annual Earnings, the Gross State Product per Capita and the Housing Finance Commitment. It is expected that coefficients of Domestic Customers, Gross State Product per Capita, the Average Annual Earnings and the Housing Finance Commitment variables are positive in the estimated equation while coefficient of Domestic tariff variable is negative.

2. Commercial Energy Consumption equation :

Econometric equation for annual Commercial Energy Consumption equation measured in MWh is to be generated from regression analysis. The independent variables to be examined in the Commercial Energy Consumption econometric equation are Commercial Consumers, Gross State Product per Capita, Commercial Tariff and the Housing Finance Commitment. All except the Commercial tariff variable are expected to have positive coefficients in the estimated equation.

3. Maximum Demand equation :

The independent variables to be considered in Maximum Demand equation are Domestic Energy Consumption and Commercial Energy Consumption. The total consumers variable does not differentiate between the classification of a consumer as being domestic or commercial, and as the classification of the consumers, peak maximum demand could change substantially. The total customers variable is not considered appropriate in estimating the maximum demand equation.

The electricity usage inter-action between the two different customer classifications is to be examined by estimating the maximum demand. Positive coefficients are expected from each of these variables in the econometric equation.

CHAPTER 4

FINDINGS

1. Factors affecting Domestic Energy Consumption :

1.1 Domestic Consumers independent variable (DC)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.971104877
R Square	0.943044681
Adjusted R Square	0.924059575
Standard Error	2697.593933
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	361470110.9	3.61E+08	49.67287
Residual	3	21831039.08	7277013	
Total	4	383301150		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	42771.48309	21049.30701	2.031966	0.135088
DC	5.254495548	0.745540788	7.047898	0.005871

94% of the variation in domestic energy consumption is determined by its linear relationship with the number of Domestic Consumers.

The standard error of the estimate is found to be 2698 MWh which is only about 1.4 %.

The F test for the DC independent variable is as follows :

Based on 5 per cent level of significance, plus one degree of freedom for the independent variable and three degrees of freedom for the denominator, the correspondent F critical value is 10.1 . The F value for variable DC is 49.7 which is greater than the F critical. The Domestic Consumers variable is considered suitable to explain the variation in the domestic energy consumption.

As expected it will be a positive coefficient, when the number of Domestic Consumers increases by one, domestic energy consumption can increase by about 5.25MWh annually.

1.2 Gross State Product per Capita independent variable (GSPC)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.529220175
R Square	0.280073994
Adjusted R Square	0.040098659
Standard Error	9590.76754
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	107352684	1.07E+08	1.167095
Residual	3	275948466	91982822	
Total	4	383301150		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	128277.6324	58107.3357	2.207598	0.114358
GSPC	2.555802815	2.365779452	1.080322	0.359104

Only 28% of the variation in domestic energy consumption is explained by its linear relationship with the Gross State Product per Capita variable. This is a very bad fit.

The F test for the GSPC independent variable is as follows :

The F value calculated for variable GSPC is only 1.2. It is less than the F critical value of 10.1 . Hence, Gross State Product per Capita variable cannot have the ability to explain the variation in the consumption of domestic energy.

1.3 Average Annual Earnings independent variable (AAE)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.894087996
R Square	0.799393345
Adjusted R Square	0.73252446
Standard Error	5062.698935
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	306408388.5	3.06E+08	11.95464
Residual	3	76892761.52	25630920	
Total	4	383301150		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	5354.434644	53706.16565	0.099699	0.926872
AAE	5.448202948	1.575741791	3.457548	0.040713

Almost 80% of the variation in domestic energy consumption can be estimated by its linear relationship with Average Annual Earnings. This is a reasonable fit.

The standard error of the estimate is 5062 MWh which is about 2.7 % difference compared to the average domestic energy consumption value.

The F test for the AAE independent variable is as follows :

The F value calculated for variable AAE is 11.9 which is greater than the F critical value of 10.1 . The Average Annual Earnings variable can have the ability to explain the variation in the domestic energy consumption.

Coefficient of AAE is a positive 5.448 as expected before the analysis. It means that as the Average Annual Earnings increases by one dollar, domestic energy consumption can increase by about 5.448MWh.

1.4 Housing Finance Commitment independent variable (HFC)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.838234749
R Square	0.702637494
Adjusted R Square	0.603516659
Standard Error	6163.856762
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	269321759.4	2.69E+08	7.088696
Residual	3	113979390.6	37993130	
Total	4	383301150		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	175820.1513	6292.641744	27.94059	0.000101
HFC	95.6244364	35.91581326	2.662461	0.076179

About 70% of the variation in domestic energy consumption is determined by its linear relationship with the Housing Finance Commitment. This is not considered as a good fit.

The F test for the HFC independent variable is as follows :

The calculated F value for variable HFC is only 7.1 which is less than the F critical value of 10.1 . Therefore, the Housing Finance Commitment variable cannot have the ability to explain the variation in the domestic energy consumption.

1.5 Domestic Tariff independent variable (DT)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.970560929
R Square	0.941988517
Adjusted R Square	0.922651356
Standard Error	2722.490785
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	361065281.8	3.61E+08	48.7139
Residual	3	22235868.22	7411956	
Total	4	383301150		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-54034.91847	35111.69759	-1.53894	0.221441
DT	21393.77345	3065.215023	6.979534	0.006037

94% of the variation in domestic energy consumption is explained by its linear relationship with the Domestic Tariff. This is a good fit.

The standard error of the estimate is 2722 MWh which is about 1.4 % of the average domestic energy consumption value.

The F test for the DT independent variable is as follows :

The calculated F value for variable DT is 48.7. This is much higher than the F critical value of 10.1 . Hence, the Domestic Tariff variable may explain variations in the domestic energy consumption.

A positive coefficient of the Domestic Tariff variable is found from the analysis. It means that as the Domestic Tariff increases by one cent, domestic energy consumption can increase by about 23,394MWh. However, the analysis result is contrary to the economic price and demand rule in a real life situation and it indicates that the Domestic Tariff variable is not a dominant factor influencing the demand in annual domestic energy consumption.

1.6 Domestic Customers and Average Annual Earnings independent variables

Result from multiple regression analysis result is as follows :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.971613503
R Square	0.944032799
Adjusted R Square	0.888065598
Standard Error	3275.079585
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	2	361848857.4	1.81E+08	16.86761
Residual	2	21452292.58	10726146	
Total	4	383301150		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	48450.32771	39577.55718	1.224187	0.345517
DC	5.693247695	2.504196001	2.273482	0.150877
AAE	-0.529942887	2.820178574	-0.18791	0.868284

94% of the variation in domestic energy consumption can be explained by its linear relationship with both the Domestic Consumers and Average Annual Earnings variables. This is a reasonably good fit. The standard error of the estimate is 3275 MWh which is only about 1.7 % of the average domestic energy consumption value.

The F test for both DC and AAE independent variables is as follows :

Based on a 5 per cent level of significance, plus two degrees of freedom for the independent variables and two degrees of freedom for the denominator, the correspondent F critical value is 19.0 .

The calculated F value for this multiple regression is only 16.9 which is less than the F critical value. Therefore, Domestic Consumers and Average Annual Earnings variables cannot have the ability to explain the variation in the domestic energy consumption up to the 5 per cent level of significance.

Moreover, the coefficient of the Average Annual Earnings found in the analysis is negative. It means that for every dollar increase in the earnings, domestic energy consumption decreases by 0.530MWh annually.

The negative coefficient found is inconsistent with the prediction for Average Annual Earnings before the analysis. This result is not believed to reflect the real life situation. People on higher incomes can afford to have, for example, airconditioners in their houses to live comfortably in a tropical climate. The end result is that electricity consumption will increase. Therefore, the Average Annual Earnings variable is expected to have a positive relationship with energy consumption.

For identifying factors affecting the annual domestic energy consumption, the Gross State Product per Capita, the Housing Finance Commitment and the Domestic Tariff independent variables do not have a direct influence in the variation of the domestic energy consumption. The Domestic Consumers variable has the most effect on the domestic consumption estimate. The multiple linear regression analysis based on the Domestic Consumers and Average Annual Earnings variables is a not a good estimate for the domestic energy consumption when compared to the simple linear regression using the Domestic Consumers variable only.

The econometric equation found to be most suitable for the annual domestic energy consumption during the period 1990 - 1994 is :

$$\mathbf{DCON = 42{,}771.5 + 5.3\ DC}$$

where DCON = Annual domestic energy consumption in MWh

DC = The number of domestic electricity consumers

2. Factors affecting Commercial Energy Consumption :

2.1 <u>Commercial Consumers independent variable (CC)</u>

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.980129396
R Square	0.960653632
Adjusted R Square	0.947538176
Standard Error	6785.894768
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	3372855064	3.37E+09	73.24592
Residual	3	138145103.4	46048368	
Total	4	3511000167		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-14541.58256	58225.98571	-0.24974	0.81891
CC	110.2883256	12.88658444	8.558383	0.003352

96% of the variation in commercial energy consumption is determined by its linear relationship with the Commercial Consumers. This is a very good fit.

The standard error of the estimate is 6786 MWh which is about 1.4 % of the average commercial energy consumption value.

The F test for the CC independent variable is as follows :

Based on a 5 per cent level of significance, plus one degree of freedom for the independent variable and three degrees of freedom for the denominator, the correspondent F critical value is 10.1 .

The calculated F value for variable the CC is 73.2 which is greater than the F critical. Therefore, the Commercial Consumers variable can have ability to explain variations in the commercial energy consumption.

A coefficient of the Commercial Consumers variable is positive as expected. So for every additional commercial customer, it is estimated that energy consumption can increase by about 110MWh annually.

2.2 Gross State Product per Capita independent variable (GSPC)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.371142781
R Square	0.137746964
Adjusted R Square	-0.149670715
Standard Error	31766.70456
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	48362961.3	4.84E+08	0.479257
Residual	3	3027370555	1.01E+09	
Total	4	3511000167		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	350225.0516	192464.1128	1.81969	0.166372
GSPC	5.424720077	7.835975231	0.692284	0.538531

Only about 14% of the variation in commercial energy consumption is explained by its linear relationship with the Gross State Product per Capita. This is a very bad fit.

The F test for the GSPC independent variable is as follows :

The calculated F value for the variable GSPC is only 0.5 which is much less than the F critical value of 10.1 . Hence, the Gross State Product per Capita variable cannot have the ability to explain the variation in the commercial energy consumption.

2.3 Commercial Tariff independent variable (CT)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.936272332
R Square	0.876605881
Adjusted R Square	0.834574507
Standard Error	12017.16514
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	3077763393	3.08E+09	21.31234
Residual	3	433236774	1.44E+08	
Total	4	3511000167		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-237336.2579	156148.6367	-1.51994	0.225852
CT	47622.796	10315.71427	4.616529	0.019126

About 88% of the variation in commercial energy consumption is estimated by its linear relationship with the Commercial Tariff. It is a reasonably good fit.

The F test for the CT independent variable is as follows :

The calculated F value for the variable CT is 21.3 which is greater than the F critical value of 10.1 . This indicates that the Commercial Tariff variable may have the ability to explain a variation in the commercial energy consumption.

A positive coefficient is found from the analysis for the Commercial Tariff variable. This means that with every one cent increase in Commercial Tariff, the commercial energy consumption is expected to increase by about 47622MWh annually. This analysis result is inconsistent with the real life situation. Therefore, it is concluded that the Commercial Tariff variable is not a significant factor influencing the demand in annual commercial energy consumption.

2.4 Housing Finance Commitment independent variable (HFC)

Result from simple regression analysis :
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.86944291
R Square	0.755930973
Adjusted R Square	0.674574631
Standard Error	16900.95061
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	265073773	2.65E+09	9.291605
Residual	3	856926394.1	2.88E+08	
Total	4	3511000167		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	435822.189	17254.07183	25.25909	0.000136
HFC	300.1854666	98.47915182	3.048213	0.055506

Only about 76% of the variation in commercial energy consumption is explained by its linear relationship with the Housing Finance Commitment variable. This is not a good fit.

The F test for the HFC independent variable is as follows :

The calculated F value for HFC variable is 9.3 which is less than the minimum required for the F critical value of 10.1 . Therefore, Housing Finance Commitment variable does not have the ability to explain a variation in the commercial energy consumption estimate.

Through the elimination process, factors not affecting the commercial energy consumption are Gross State Product per Capita, Commercial Tariff and Housing Finance Commitment variables.

The econometric equation found to be most suitable for the annual commercial energy consumption for the period 1990 - 1994 is as follows :

$$\mathbf{CCON = -14{,}541.6 + 110.3\ CC}$$

where CCON = Annual commercial energy consumption in MWh

CC = The number of commercial electricity consumers

3. Factors affecting Maximum Demand :

3.1 Domestic Energy Consumption independent variable (DCON)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.963126247
R Square	0.927612167
Adjusted R Square	0.903482889
Standard Error	4.770560984
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	874.9052437	874.9052	38.44343
Residual	3	68.27475632	22.75825	
Total	4	943.18		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-143.3153672	46.64598949	-3.0724	0.054459
DCON	1.513755461	0.244143218	6.200277	0.008453

About 93% of the variatión in maximum demand is determined by its linear relationship with the Domestic Energy Consumption. This is a reasonably good fit.

The standard error of this estimate is 4.8MW which is about 3.3 % of the average maximum demand value.

The F test for the DCON independent variable is as follows :

Based on a 5 per cent level of significance, plus one degree of freedom for the independent variable and three degrees of freedom for the denominator, the correspondent critical value for F is 10.1 .

The calculated F value for the variable DCON is 38.4 which is greater than the above F critical value. Therefore, the Domestic Energy Consumption variable can have ability to explain variation in the maximum demand estimate.

The coefficient found for the DCON is positive as expected. It means that as the annual Domestic Energy Consumption increases by one GWh, the maximum demand can be expected to increase by 1.5MW.

3.2 Commercial energy Consumption independent variable (CCON)

Result from simple regression analysis :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.883204322
R Square	0.780049874
Adjusted R Square	0.706733166
Standard Error	8.3156992
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	735.7274404	735.7274	10.63946
Residual	3	207.4525596	69.15085	
Total	4	943.18		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-75.62789152	67.92537695	-1.1134	0.346717
CCON	0.457914993	0.140386439	3.261818	0.047067

About 78% of the variation in maximum demand is explained by its linear relationship with the Commercial Energy Consumption.

The standard error of the estimate is 8.3MW which is about 5.7 % of the average maximum demand value.

The F test for the CCON independent variable is as follows :

The calculated F value for the variable CCON is 10.6 which satisfies the F critical value of 10.1. Hence, Commercial Energy Consumption variable can have the ability to explain variations in the maximum demand estimate.

The coefficient of CCON variable is also found to be positive from the analysis and is consistent with the predicted relationship. Therefore, as the annual Commercial Energy Consumption increases by one GWh, it is expected that the peak maximum demand can also increase about 0.5MW.

3.3 Domestic & Commercial Consumption independent variables (DCON & CCON)

Multiple regression analysis result is as follows :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.996982942
R Square	0.993974986
Adjusted R Square	0.987949973
Standard Error	1.685626339
Observations	5

ANOVA

	df	*SS*	*MS*	*F*
Regression	2	937.4973277	468.7487	164.9747
Residual	2	5.682672309	2.841336	
Total	4	943.18		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-192.8878332	19.5756331	-9.85347	0.010143
DCON	3.31539348	0.39343067	8.426881	0.013791
CCON	-0.609140931	0.129783471	-4.69352	0.04252

More than 99% of the variation in domestic maximum demand is determined by its linear relationship with both the Domestic Energy Consumption and the Commercial Energy Consumption variables. This is a very good fit.

The standard error of the estimate is 1.7 MW which is about 1.2 % of the average maximum demand.

The F test for both DCON and CCON independent variables is as follows :

Based on a 5 per cent level of significance, plus two degrees of freedom for the independent variables and two degrees of freedom for the denominator, the correspondent of the F critical value is 19.0 .

The calculated F value for this multiple regression is 165.0 which is much greater than the value of F critical. Hence, the Domestic Energy Consumption and the Commercial Energy Consumption variables can have the ability to explain variations in the domestic energy consumption up to a 5 per cent level of significance.

Coefficient of the DCON variable is positive. Therefore, as the Domestic Energy Consumption increases by one GWh, it can be expected that the maximum demand increases by approximately 3.3MW, thereby holding the Commercial Energy Consumption variable constant.

In case of CCON variable, its coefficient is changed to negative. This means that as the Commercial Energy Consumption increases by one GWh, the maximum demand is expected to decrease by about 0.6MW, while holding the Domestic Energy Consumption variable constant.

The econometric equation found to be most suitable for estimating the maximum electricity demand for the period 1990 - 1994 is :

$$\mathbf{DM = -192.89 + 3.32\ DCON - 0.61\ CCON}$$

where DM = maximum electricity demand in MW

DCON = Annual Domestic Energy Consumption in GWh

CCON = Annual Commercial Energy Consumption in GWh

CHAPTER 5

SUMMARY and CONCLUSION

The growth rate of established residential homes and business establishments in Darwin has increased considerably over the past five years. This has been brought about by the relocation of the 2nd Calvary into the Palmerston area and the associated family relocation programme which should continue until the year 2000. As electricity energy cannot be stored in any large quantity, the essential task of the Supply Authority is to forecast the future demand while avoiding either shortages or over-investment in generation capacity. The purpose of this research project is first to identify the most relevant independent factors that play the most important roles in estimating the annual domestic and commercial energy consumption and maximum electricity demand and to estimate corresponding values via econometric equations.

Data collection taken from the Power And Water Authority Annual Reports and the Australian Bureau of Statistics publication are the basis information for the analysis. Various types of independent variables are examined for their suitability to be included in the study. They include Darwin population statistics, the number of electricity consumers connected, the tariff structure, an average of annual earnings, the gross state product per capita, the housing finance commitment and local weather conditions. Each of these independent variables is assessed in relation to an appropriate dependent variable through the simple regression analysis based on the least squares technique. Relevant independent variables are then applied to the multiple linear regression analysis to estimate econometric equations.

At a 5% level of significance, the domestic customers variable is foremost in estimating the annual domestic energy consumption. For every additional domestic electricity consumer, it is expected that there will be an increase of 5.3 MWh in annual domestic energy consumption. A similar result is found for the case of identifying independent variables in the annual commercial energy consumption equation. It is found that for every new commercial electricity customer applying for connection, the annual commercial energy consumption is estimated to increase by 110.3 MWh. The econometric equation for maximum demand has been estimated from the independent variables of domestic and commercial energy consumption. For every gigawatt-hour increase in the annual usage of domestic consumption, it is estimated that the maximum demand for electricity can increase by 3.32 MW annually. However, for every gigawatt-hour increase in annual usage in the commercial consumption, it is estimated that the maximum electricity demand can decrease by 0.61 MW. This can be explained by demand side management and differing patterns of power usage between the two distinctly different types of consumers.

The weakness of this study is that the collection of data only covers a period of five years (1990 - 1994). This explains why so few independent variables are found best suitable for inclusion in the equation, particularly in the case of annual domestic and commercial energy consumption. Therefore, it is recommended that five years into the future, a broader sample of population should be collected to investigate the effects of other independent variables on the consumption of power.

The average growth rates of domestic and commercial customers has been 3.1% and 2.4% respectively during the period from 1990 to 1994. With an installed generating capacity of 230 MW (maximum demand) at the Channel Island Power Station, it is assumed that the growth rate of both domestic and commercial customers will increase at 3% annually. The existing power station will be expected to produce the power to provide for this growth rate until the year 2002 when it will exceed its capacity. Therefore it should be concluded that these forecast equations could provide the Supply Authority with a means of planning plant augmentation or expansion in order to keep up with future consumer demand.

REFERENCES

1. Power And Water Authority of the Northern Territory, Annual Report, 1990, 1991, 1992, 1993 and 1994.
2. Australian Bureau of Statistics, Northern Territory in Focus, 1992, 1993 and 1994.
3. Sekaran, U. (1992), Research Methods for Business : A Skill - Building Approach, New York : John Wiley.
4. Northern Territory Electricity Commission (1985), Darwin Load Forecast Report, Planning Section.
5. Power And Water Authority of the Northern Territory (1990), Darwin Load Forecast Report, Planning Section.
6. Power And Water Authority of the Northern Territory (1993), Darwin/Katherine System Load Forecast Report, Planning Section.
7. Electricity Supply Association of Australia (1990), The Electricity Supply Industry in Australia.
8. Doran, H. and Guise, J. (1984), Single Equation Methods in Econometrics : Applied Regression Analysis, Armidale : University of New England.
9. Mason, R and Lind, D. (1993), Statistical Techniques in Business and Economics, Boston : Irwin.