BARBADOS

NO.: FTC02/09 BL&P – RADJ

FAIR TRADING COMMISSION

IN THE MATTER of the Utilities Regulation Act, Cap. 282 of the Laws of Barbados;

AND IN THE MATTER of the Utilities Regulation (Procedural) Rules, 2003;

AND, FURTHER, IN THE MATTER of the Application by The Barbados Light & Power Company Limited for a Review of Electricity Rates pursuant to Section 16 of the Utilities Regulation Act, Cap. 282.

The Barbados Light & Power Limited **APPLICANT**

AND

Office of Public Counsel **INTERVENORS**

Barbados Association of Retired Persons

Barbados Small Business Association

Sentinel Group Caribbean, Inc.

Barbados Consumer Research Organisation, Inc. (BARCRO)

Canbar Technical Services Ltd.

Barbados Association of Non-Governmental Organisations (BANGO)

Mr. Douglas B. Trotman

Dr. Roland Clarke

Mr. Errol Niles

WRITTEN CLOSING SUBMISSIONS OF THE BARBADOS CONSUMERS RESEARCH ORGANISATION, INC., (BARCRO) – RATE REVIEW HEARING.

INTRODUCTION

1. In accordance with a ruling on day 13 of this Rate Review Hearing conducted by the Fair Trading Commission (FTC) that following receipt of all the transcripts, written closing submissions are permitted. In this connection we hereby submit the said submissions.

THE APPLICATION

2. Notwithstanding that the Application is fairly well put together and lacks the errors that featured in the 1983 Application and Rate Hearing, it is our judgement that its timing leaves a lot to be desired. There is a global economic meltdown that engulfs our little island, which will be the same size when we awake tomorrow. By no stretch of the imagination are these times to be considered normal. We acknowledge, however, the task of deciding what the Application merit, or its lack thereof, rests with the Commission.

3. In the Affidavit of Hilary Malcolm A. Gibbs-Taitt, Esq., it states, "From my perusal of the documents of the application, I am unable to give an honest and fair analysis of the merits of the Application. With the privilege of perusing more information, as the Hearing goes on, it is possible that the case of the Applicant will be more illuminating. One question that exercises my mind, how will the crystallising of evidence convince any reasonable and right-thinking person how a people, struggling to manoeuvre through the murky waters of a recession that is globally **affected (our correction)**, be able to survive increases, at this time?"

4. Further, in the Affidavit of Carl Leon Ince, Esq., he stated, "From my understanding, it seems that the timing of this Application is less than opportune. There is a World-wide Recession that some reputed Economists regard as a Depression – excepting only China and Hong Kong – and that will severely impact, negatively Small Island Developing States in a way that has not been witnessed anytime in the past. This is too much a worry to dismiss its negative impact on Barbados."

5. With the benefit of two (2) pre-hearing days and thirteen (13) consecutive week-days of a Hearing, we are still of the view that the overriding Global socio-economic environment is in a severe state of shock, never before witnessed anytime during the history of mankind, for the matter at hand to be treated lightly. Furthermore, nothing has changed, either in the world or, more particularly, in Barbados that will change this view in the near future.

6. With a ***recession*** (meaning=depression, slump, downturn, collapse, decline; opposite=boom) in existence, some economists go further and call it a ***depression*** (meaning=despair, sadness, gloominess, misery, hopelessness, melancholy, dejection, opposite=happiness). One look at these two words sums up the state of each perfectly: the economist will tell you that while ***recession*** speaks to the state of the economy, generally; a sociologist will confirm that ***depression*** addresses the state of mind of people during these times.

7. We, nevertheless, agree to the removal of the 2.64 cents/kWh from the base energy charge for all tariffs and for the fuel to be incorporated in the fuel charge adjustment (FCA).

8. The Applicant states that based on the estimated earnings during the Test Year of 2008 there is a deficiency of $28, 221, 603 to give a yield of 10.48%. During the Test Year the rate of return was stated as 6.07%. To reach this new requirement means a change of some 72.65% increase. In the present economic climate this is excessive.

9. It is to be noted that because of the recessionary times prevailing, interest rates are very low indeed.[1]

10. Unlike the 1983 Hearing when the Public Utilities Board (PUB) was seized with the full details of known Capital expenditures the FTC is not so held. The BL&P is still a private company and we are, therefore, not minded to treat its consumers as if some kind of regulated or classified shareholders that evoke a privatisation. Moreover, in clear testimony before the Rate Hearing, expert witness, Mr. Robert Camfield, [2] could not **"tell precisely what the cost of capital is..."**

11. The 2, 700 shareholders of this company are the beneficiaries of the profits over the past 26 years, following the rate increase handed out by the PUB in 1983. By the Applicant's own admission, some 72% of profits have been reinvested in the business. That leaves 28% for the benefit of its shareholders. The Applicant's consumers, on the other hand, have had the benefit of electricity for which they have duly paid.

12. It must be in the interest of everyone and the consumers of BL&P that a fair and reasonable profit be made each year. We should expect no less and,

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[1] Pages 556, 557, 558 of the ***Transcript of Proceedings*** Day 6; Wednesday, 14 October, 2009. Expert Witness, Mr. Robert Camfield being questioned by Mr. Clyde Mascoll.

[2] Page 576 [307 – 327] of the ***Transcript of Proceedings*** Day 7; Thursday, 15 October, 2009. Expert Witness, Mr. Robert Camfield being questioned by Mr. Clyde Mascoll.

certainly, no more. We cannot ignore the impact of a rate increase on the consumers of the utility. The BL&P can show that great strides have been made by increasing the amount of customers since 1983 but this is not sustainable. This is further compounded by the fact that the demographics of our society are challenged by the fact that the birth rate is a dismal 0.02 per cent increase per year while, at the same time, we are experiencing a phenomenal growth in the elderly population, which continues apace. There is no need to debate facts.

13. There is no change to the rates that came into effect in 1983. There is no change to the 2.64 cents p/kWh that will impact the FCA calculations. The only change we know about is the amount charged for the FCA, currently in force, together with the changes caused by the changing price of oil on the world markets and already the Call-in Programmes are full of complaints from angry consumers that the amount they pay has sky-rocketed. Is this not telling us something that should not be ignored?

14. After all, during the 23 years from 1983 to 2005, BL&P's Audited net income, prepared in accordance with the Historical Cost Convention as modified by the revaluation of property, plant and equipment, racked up profits of $220.948 million. For the 3 years from 2006 to 2008. Audited net incomes, without modifications, were $95.090 million or $31.697 million per year. It is to be noted that during those 26 years the Grand Total of, at least, $316.038 million have accumulated and, for not one year did BL&P make a loss.

15. When the profits for the 23 years are treated with the methodology as the last 3 years, we find that the net profits are dramatically increased to the point we ask where is the need for an increase on the scale of the Application.

16. The Minister of Economic Affairs, Dr. The Hon. David Estwick, stated on 2 October, 2009 that the outlook for Barbados remained volatile (meaning of volatile: unstable, unpredictable, explosive, hot-blooded, impulsive, fickle, capricious, hot-tempered). He added that activity in its major industries was expected to decline further, **"thus negatively impacting employment in that sector and even reducing some of the welfare gains made over the past decades."**

17. We remain very concerned for the proverbial **"little old lady"** who will have severe challenges to pay her own electric bills as well as assisting every business to pay their electric bills when she deals as a buyer of goods and services. This fact is extended to each and every one of us, too.

18. Here is a company doing so well, following the Rate increase handed down by the PUB in 1983 that it was able to set up its own self-insurance fund, thus minimising its own risks since BL&P does not pay commercial insurance.

BURDEN OF PROOF

19. We agree that the burden of proof must rest on the Applicant to show that the proposed rates are fair and reasonable, as stipulated in Section 14 of the Act.[3]

20. Can the Commission ignore the fact that in granting the Applicant its case the consumers of the utility will never own any of the capital structures? Whereas, the shareholders will continue to operate as the closed shop that they have become. Is it not probable that the said shareholders could finance the capital structures? Could it be more probable than not that a methodology, which would allow a sizable amount of the Applicant's consumers to become part of the shareholding democracy and thus finance the capital projects by the issuing of shares?

21. Instead of the heavy reliance on the Bonbright principle, as outlined by leading Counsel to the Applicant in his opening statement that some adherence to the End-result theory be accommodated so as to have a win-win situation for both supplier and consumer.

ROLE OF THE COMMISSION

22. The Commission, in its role as the regulator, should be capable of weighing the scales of justice to see that the rates are fair and reasonable so as to take into account the well-being of the consumer, on the one hand, and to be mindful that the supplier receives a return on its investment rather than look to the consumer for the investment and charge the same consumer the full rate, without any returns. At least the employees and pensioners of the BL&P receive preferential rates.

23. We agree that the doctrine of ***stare decisis*** [4] should obtain.

24. The Commission has statute to be its guide and Sections 3(1)(a)(b)[5]; 3(2)(3)[6]; 10(a)(b)[7], under the Act referred.

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[3] Refer S. 14 **Utilities Regulation Act, CAP.282: "In any proceeding before the Commission involving an existing or proposed rate of a service provider, the burden of proof to show that the rate is fair and reasonable and in accordance with the principles established by the Commission, shall be upon the service provider."**

[4] See Brief Review of the ***Doctrine of Stare Decisis.***

[55] Refer S. 3(1),(a),(b) Utilities Regulation Act, CAP.282

[6] Refer S. 3(2), (3) Utilities Regulation Act, CAP.282

[7] Refer S. 10 (a), (b) Utilities Regulation Act, CAP.282

THE WITNESSES

25. We need to refer to three (3) witnesses of the Applicant, Messrs. Camfield, O'sheasy and Worme, in that order.

26. Mr. Robert Camfield in his evidence made it clear that the Applicant never showed any interest in the consumers of the BL&P. It came across as an honest statement from an expert witness.

27. Mr. Michael O'sheasy tried to do some damage control but we are still of the view that the honesty of Mr. Camfield was paramount.

28. As someone so closely attached to BL&P, Mr. Steven Worme came across as very knowledgeable though at times he appeared to be patronising.

29. The Barbados Consumers Research Organisation, Inc. (BarCRO) was prepared to bring a witness to challenge the Application of the BL&P. At the Issues Conference, BarCRO served a Notice of Motion. Under the heading, Additional Issues, notice was served of the following:

INTERVENER FUNDING

1. It be agreed that **OUT-OF-POCKET EXPENSES and HONORARIA** be paid to **Intervenors** and that **WITNESSES, as may be summoned by Intervenors,** be recompensed as per a schedule, in accordance with standard accounting procedures that shall be determined, at an **ISSUES CONFERENCE** of the Fair Trading Commission.
2. Accountability, transparency and methodology to be part of the order.

28. We had sought the services of Mr. Lindsay Holder who is a noted Economist that he would be our witness to test the claims of the Applicant. Mr. Holder, quite rightly, demanded to be treated, financially, the same way any witness is treated by the Applicant.

29. On the issue of involving a witness, the Commission ruled that any witness we bring should be **"public spirited"**.[8] Yet, it never became clear if the lead Counsel, other Counsels and Consultants or any of the witnesses appearing for the Applicant will do so in a public spirited way. Are we to believe that this is the way justice works? We do not think so. This is effectively the reason why BarCRO did not call any witnesses of fact or expert witnesses to contradict the evidence of the Applicant. We are, nevertheless, proud to see that Mr. Clyde Mascoll, Economist, is willing to be a part of the process.

[8] See pages 18 – 25, ***Transcripts of Proceedings of Issues and Technical Conference,*** Thursday, 3 September, 2009. The Commission was somewhat dismissive of the Additional Issues, as the Transcripts will testify.

30. The FTC never addressed the issue of witnesses appearing for the consumers; this was not addressed by The Office of Public Counsel either. This, therefore, is a serious omission. This is ridiculous and a travesty of justice. Since no one is suggesting that the Lawyers, Consultants and those attached to the BL&P and putting the case for the Applicant and, hence, against the consumers who will be the eventual payers, be public spirited, it is a gross insult to our justice system to deny WITNESSES, putting the case on behalf of consumers, equality of opportunity. This is not equity.

31. There is a cost for justice but to show that the results are fair and reasonable; injustice, too, carries a cost, except that added to that burden are unfairness and unreasonableness, being the attendant baggage that the consumers eventually must carry; until one day they will demand a stop be executed.

RATE BASE

32. It is a concern that the BL&P Rate Base is about the same or higher than most of the States in America, as testified by one Expert Witness. In fact, it was suggested that Barbados compares favourably with about only three (3) States.

33. Consumers are the payers of the goods and services they seek. It goes without saying that in order to pay one has to have the ability to purchase. This is only possible from one's earned income or, in the case of Pensioners, fixed income. It is generally accepted that for a similar job, the American equivalent pays some three (3) to four (4) times what obtains in Barbados. How is it possible for consumers of Barbados to be saddled with ever increasing rates? It is generally accepted that for a similar job, the American equivalent pays some three (3) to four (4) times what obtains in Barbados. How is it possible for consumers of Barbados to be saddled with ever increasing rates and, particularly, when these same people do not own any of the Capital structures. The only people to benefit are the shareholders.

34. Much talk has indicated that all customers of the BL&P have to do is conserve energy uses in order to make savings. A study has shown that the ***"demand for electricity is a derived demand in that consumption of electricity does not yield any utility but rather is an input into durable goods that do yield utility."***[9]

35. In another study, it is shown that in the Caribbean energy consumption grew at a faster rate compared to their economies.

[9] Source: ***Price Reform and Household Demand for Electricity*** by Adrian Carter, Marketing and Communications Department, BL&P; Roland Craigwell and Winston Moore, University of the West Indies.

36. The argument is **"that policies for energy efficiency should be long-term in nature and should encourage proper market and pricing signals."** [10]

CONCLUSION

37. The Barbados Consumers Research Organisation, Inc. (BarCRO) wishes to thank everyone who is involved in the process of this Rate Hearing. We thank the Commissioners for their patience in extending the representation of our organisation where we aim to address the needs of consumers. It is our belief that all of us are consumers, unless by the mere dent of our wealth or ignorance, we opt out of this calling. If our call for fairness is heeded, the remarkable thing is that many other persons will benefit. We extend our thanks to the FTC as a whole for the excellent way in which they cooperated throughout the Hearing. Let us say thanks to all members of the Applicant. We are mindful that without consumers there is no need for the supplier or for the FTC. We extend thanks to all Intervenors but must single out Mr. Clyde Mascoll for the difference he made to this Hearing. We hope that when the decision is finally made it will benefit our country as a whole.

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[10] Study: ***"Energy Consumption and Economic Growth in Latin America and the Caribbean: A Panel Cointegration Approach" by Troy Lorde, University of the West Indies and Kester Guy, Central Bank of Barbados.***

DATED 10 NOVEMBER, 2009.

PREPARED ON BEHALF OF INTERVENOR,

BARBADOS CONSUMERS RESEARCH ORGANISATION, INC., (BarCRO)

WHOSE REPRESENTATIVES ARE:

MESSRS. CARL LEON INCE AND HILARY MALCOLM A. GIBBS-TAITT.

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HILARY MALCOLM A. GIBBS-TAITT

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TEACHING *STARE DECISIS*

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One of the first challenges in teaching any introductory law course is communicating the nature of common law and the role of ***stare decisis*** in its development. Understanding how common law develops through the doctrine of ***stare decisis*** is critical for students, but particularly difficult when first being introduced to the law. Fortunately, there are a variety of legal doctrines currently under development, particularly in the high tech environment, that offer superb living examples of ***stare decisis***.

A BRIEF REVIEW OF THE DOCTRINE OF STARE DECISIS

The doctrine of stare decisis is the policy of courts to abide by, or adhere to, previously decided cases. In general, once a court has decided a matter, it will decide subsequent cases containing substantially similar facts consistent with its earlier decisions.
1 Previous cases become binding precedent for future cases. When a matter comes before a court, therefore, it looks to past cases to determine present issues.

2 An integral element of ***stare decisis*** is also which courts have binding authority over other courts. Where a court's decisions are binding on inferior courts, previously decided cases from the superior court become binding precedent for future matters in inferior courts. Concomitant with the notion of the consistency provided by the doctrine of ***stare decisis***, if a court cannot find binding precedent for a particular issue, it will look to previous cases from non - binding courts in an effort to find guidance so that, again, consistent law can be developed for emerging issues.

In a common law system, where the body of law develops case-by-case, the doctrine of stare decisis is critical for the development of a consistent and reliable body of law. But the actual process is not so simple. Trial courts are not bound by other trial court decisions, and therefore can rule differently on the same issue. In addition, each state has its own body of common law, developed independently of the other states.

Price Reform and Household Demand for Electricity

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Price Reform and Household Demand for Electricity

Abstract

This paper estimates a model of residential electricity demand to project the impact of proposed tariff changes on a representative sample of 130 Barbadian households. The results from the demand function suggest that the price elasticities of demand for particular appliances varied significantly, with households that utilize solar water heating being more price elastic than households that use air conditioning and electric water heating . The income effects were, however, statistically insignificant as they may have been captured by choices of appliances rather than utilisation. The income elasticity for households with solar water heating was found to be negative, probably reflecting the substitution impact arising from the use of solar power to provide water heating. The database also allowed the authors to breakdown price and income elasticities by individual households and these results suggest that middle-income households tend to be more prices sensitive, indicating that these households may be more able to reduce their usage of discretionary appliances than low-income households. The propose changes in the electricity rate structure was investigated and determined to likely have very little influence on households demand for electricity. Changes in consumption will however be more noticeable within upper consumption and upper income households.

JEL Classification: Q41; C24; O54

Keywords: Electricity demand; Price Reform; Heckman estimator; Developing country

1. Introduction

The Barbados Light and Power Company (BL&P), which under current law, is the only electricity service provider in Barbados, has recently been given permission by the Fair Trading Commission (FTC), to submit its application for a review to its rates and rate structure, which have not been changed since 1983. This action was required as it was thought that the current rates do not permit the BL&P to maintain its reliability and efficiency as well as to satisfy lenders and attract new capital. One aspect of these proposed reforms that are likely to be important to the deliberations between the FTC and the BL& P is the effects of these price revisions on consumption which will depend on the price elasticity of demand for electricity. The latter would require knowledge of demand for electricity studies in as much details as possible.

This paper estimates a demand for electricity function for Barbados to assess the impact of the proposed rate changes on consumers. For the first time, survey data on Barbadian households are utilised. Past electricity demand studies for Barbados (Cox, 1978; Durant, 1991; Mitchell, 2009) have not addressed policy issues like the one proposed above and have been based on aggregate time series macro data of the country. For instance, aggregate electricity consumption is usually regressed on an income variable and a price variable over various time periods with stationary and non-stationary time series econometrics techniques. No work has been done employing micro-level data or micro-econometrics. Some authors have recently shown that the use of micro-level data, which reflects individual and household behaviour more closely, can add detail to an understanding of the nature of consumer responses (see, for instance, Hawdon, 1992; Nesbakken, 1999; Holtedahl and Joutz, 2004; Louw et al., 2008). Microeconomic approaches to energy and electricity demand modelling also enable an analysis across different heterogeneous household groups and allow for the incorporation of a wide variety of household characteristics within the estimated equations (see Hawdon, 1992).

The demand for electricity services is a derived demand where households desire certain energy-using appliances and require electricity to power these durable goods

(Dubin and McFadden, 1984). Hence, it would be appropriate to model the electricity demand for individual appliances; however, data at this level of disaggregation is not available. Electricity demand is therefore modelled as the sum of the electricity used by appliance categories.

Like most electricity providers around the world, the price of electricity services supplied in Barbados are non-linear, in that on top of a fixed customer fee a three-tier price schedule is employed. This type of household demand function requires the application of the usual censored regression modelling techniques. In this paper, the model is estimated using the Heckman two-step approach (see Cameron and Trivedi, 2005 for details). Due to the existence of non-linear pricing, Reiss and White (2005) elasticities on the marginal and average price as well as income variables are calculated.

Once the electricity demand function is shown to give reasonable findings, it can be used to project the impact of the tariff changes on the Barbadian consumers, by adjusting the price variables while leaving the other variables unchanged. The results imply that the propose new rate structure is generally not likely to have a significant impact on households demand for electricity.

In the following section, the background to the rate adjustment is discussed. After that, a brief review of the demand for electricity literature is provided. Then the empirical approach, which consist of the conceptual set up, the econometric methodology and data is presented. Next the statistical results are discussed and the paper closes with a brief conclusion.

2. Background to Rate Application

The BL & P submitted an application for a review of its rates and rate structure to the Fair Trading Commission (FTC) on May 8, 2009. The previous application for a review of rates by the BL&P was in 1983 when the then Public Utilities Board granted the company an increase in its basic electricity rates. The BL & P indicated that the present rate application is being made because the current rates are inadequate for the

Company to continue to meet its operating and maintenance expenses, satisfy lenders and attract new capital to replace older plant. Some of the main objectives of the rate application as outlined by the Company include:

i. The provision of fair rates and to apportion the total cost of service among the different classes of customers in a fair manner, sensitive to any impact on customers.
ii. To encourage customers to use electricity more efficiently by, revising the existing rates to more closely reflect the unit cost of serving customers, thereby reducing the inter and intra class subsidies that presently exist;
iii. To shift the 2.64 cents per kWh of fuel cost from the base energy rate to the Fuel Clause Adjustment (FCA) so that the full fuel cost is collected through the FCA;
iv. To revise the Service Charges so that they may more closely reflect the cost of service; and
v. To lessen the rate impact of the overall revenue increase on customers in the lower income bracket.

The rate application is proposed to affect the structure of all of the Company's existing tariff groups. The Domestic Service tariff group which services residential customers, is expected to see changes to its fixed domestic customer fee and the base energy charge. Currently domestic service customers are first charged a BDS$3 fixed customer fee, on top of an inclining three-tier price schedule (Figure 1). Customers using up to 100 kWh presently have to pay BDS$0.176 per kWh. Those customers utilizing in excess of 100 kWh are charged BDS$0.196 for the next 900 kWh and BDS$0.216 for each additional kWh above of 1000 kWh. The BL&P is therefore seeking permission to adjust the customer charge to an inclining block price structure where customers that consume less than 100 kWh on average over a twelve month period will be charged a BDS$6 monthly fee, while the customer price will increase to BDS$10 for those consuming between 101 and 500 kWh and BDS$14 for those customers consuming a monthly twelve month average above 500 kWh.

A four-tier inclining block rate is proposed for the base energy charge that is expected to see the exclusion of the 2.64 cents per kWh that presently goes towards the fuel cost being shifted from the base energy rate to the FCA. It is proposed that customers using up to 100 kWh will be charged BDS$0.150 per kWh, while those consumers utilising in excess of 100 kWh would have to pay BDS$0.176 per kWh for the next 400 kWh. Customers using in excess of 500 kWh will pay a price of BDS$0.200 per kWh for the next 1,000 kWh and BDS$0.224 per kWh for any consumption greater than 1,500 kWh (Figure 1).

3. A Brief Review of the Literature

The demand for electricity is a derived demand in that consumption of electricity does not yield any utility but rather is an input into durable goods that do yield utility. Taylor (1975) argues that it is important to understand from the outset the differences between long-run and short-run electricity demand. In the short-run, electricity demand generally arises from the utilisation of durable goods, while in the long-run demand can be influenced by the stock of these goods the consumer demands.

One of the earliest studies on residential household demand is provided by Houthakker (1951), using observations from 42 provincial towns in the United Kingdom between 1937 and 1938. The annual average electricity consumption per customer was regressed on average money income per household, the marginal price of electricity, the marginal price of gas and average holdings of heavy equipment. Houthakker reports that the income elasticity of demand for electricity was about 1.2, while the price elasticity of demand was -0.9. One of the main shortcomings of this early study was that the author did not explicitly attempt to model either the short-run or the long-run. In a follow-up study, however, Houthakker and Taylor (1970) use a two-equation model of personal consumption expenditures on electricity, where consumption is modelled as a function of stocks, income and relative prices, while the change in stocks of durable goods is equal to electricity consumption and depreciation. The study finds that while in the long-run the absolute values for income and price elasticity of demand are around 2, in the short-run, electricity demand tends to be relatively price and income inelastic (about 0.1); comparable results are obtained by Mount et al., (1973), Anderson (1973), Houthakker et al., (1973) and Griffin (1974). Taylor (1975) notes that most of this early literature finds that the price and income elasticity of demand for electricity is larger in the long-run and electricity demand tends to be fairly price and income elastic in the long-run. These results were by and large derived from highly aggregated data.

Given this criticism of the early literature, Parti and Parti (1980) employ a database of more than 5,000 individual households from the San Diego County in 1975. Noting that the consumption of electricity is derived from the utilisation of appliances, the study first attempts to account for the expected electricity usage given the appliances in the household. Actual usage is then explained by the presence of the following characteristics: an air conditioner; square footage of residence; weighted average of the average electricity prices in the previous two months; household income; presence of electric space heater; presence of electric water heater; number of people in household; number of appliances in the common effect category, and; the number of non-refrigerator appliances in the common effect category possessed by the household. The results suggest that the short-run price elasticity of demand was about -0.6 and the income elasticity of demand was 0.2. These estimates were quite similar to the earlier papers using aggregate time series data. Rather than separating the demands for non-durables and electricity separately, Dubin and McFadden (1984) develop a unified model of the demand for consumer durables and the derived demand for electricity. When this is done, the price elasticity estimates for income fall to 0.02, while that for price elasticity declines to -0.3. Similar lower short-run elasticities are obtained by Munley et al., (1990) for multi-family, renter-occupied residences as well as Maddock et al., (1992) in the case of Colombia.

Reiss and White (2005) estimate a model of residential electricity demand using a representative sample survey of 1307 California households. The survey collects information not only on electricity consumption, but also on household appliances, physical characteristics of the residence as well as demographic household information.

The reported results suggest that the price elasticities of demand for particular appliances varied significantly. However, air conditioning had the highest price elasticity of demand of the five appliance types considered. The income effects were, however, statistically insignificant as these effects may have been captured by choices of appliances rather than utilisation and agree with studies by Parti and Parti (1980) and Dubin and McFadden (1984). In terms of household price and income elasticities, Reiss and White report that the mean annual electricity price elasticity for California households was about -0.4, which is within the range reported by previous studies, while the income elasticity was zero.

4. Empirical Approach

4.1 Conceptual Framework

In electricity demand studies it is customary (see Dubin, 1985; Varian, 1992; Filippini and Pachauri, 2002; Holtedahl and Joutz, 2004; Louw et al., 2008) to assume that the household demand for electricity is derived from the demand of the commodity itself (electricity) and the service that electricity provides (i.e. being able to operate domestic appliances, televisions, etc.). Therefore, a general household utility function incorporating the household's electricity demand would generally take the form of

$$U = u\left(s(E, A, F), y, z\right) \qquad (1)$$

$$s.t. \; m < p_s s + p_y y$$

where s is the energy services consumed by the household, E is electricity, A are appliances, F are other fuels consumed by the household, y are goods and services consumed by the household, z represents the tastes and preferences of the household, m is the income of the household, p_s is the price of energy services and p_y are the prices of the other goods and services consumed. With maximising household utility being the objective, the Lagrange function given below can be formed:

$$\mathcal{L} = u\left(s(E, A, F), y, z\right) - \lambda\left(p_s s + p_y y - m\right) \qquad (2)$$

The first-order conditions from this Lagrange function allow us to derive Marshall Demand function for the household's demand for energy services as follows:

$$x = x^{*}(p_x, m, z, \varepsilon) \qquad (3)$$

The household's tastes and preferences (z) are incorporated in the demand function as they form part of the decision process in determining which fuels are used by the household as well as they reflect any externalities that may impact on health and productivity. The stochastic term, ε, is added to the equation for estimation purposes.

4.2 Econometric Approach

Like most electricity providers around the world, the price of electricity services supplied in Barbados are non-linear. As mentioned in Section 2 domestic services are first charged a BDS$3 fixed customer fee, on top of this fee a three-tier price schedule is then employed (Figure 1).

Given this non-linear pricing schedule, Reiss and White (2005) note that the stochastic term in Equation (3) conveys information about the willingness-to-pay of the consumer, i.e. consumers self-select the marginal price they are willing to pay. The demand function for the household under a three-tier pricing schedule therefore takes the following form:

$$x^{*} = \begin{cases} x(p_x^{1}, m^{1}, z; \beta) + \varepsilon & \text{if } \varepsilon < c_1 \\ x(p_x^{2}, m^{2}, z; \beta) + \varepsilon & \text{if } c_1 < \varepsilon < c_2 \\ x(p_x^{3}, m^{3}, z; \beta) + \varepsilon & \text{if } c_2 < \varepsilon < c_3 \end{cases} \qquad (4)$$

Equation (4) is a censored regression model that can be estimated using the usual censored regression modelling techniques. The model is estimated utilising the Heckman two-step approach (see Cameron and Trivedi, 2005).

As noted in Section 3.1, the demand for electricity services is a derived demand where individuals consume certain energy-using appliances and therefore desire electricity to power these durable goods (Dubin and McFadden, 1984). In this instance, modelling the electricity demand for individual appliances would be preferred; however, data at this level of disaggregation is not available. Consequently, electricity demand is modelled as the sum of the electricity used by [illegible] appliance categories:

[illegible] (5)

where [illegible] are the slope coefficients that depend on the household's holdings of particular appliances with [illegible] being a dummy variable that takes a value of 1 if the household holds appliance [illegible] and 0 otherwise. Following Dubin and McFadden (1984), the choice of space cooling and water heating are isolated, while the other appliances are treated as statistically exogenous. There are two motivations for making this simplifying assumption: (1) this approach increases the degrees of freedom as a smaller set of interaction terms are employed, and; (2) space and water heating are major consumption decisions that require significant retrofitting of the house. In contrast, the other appliances usually do not require such substantial investments.

4.3 Data

The empirical electricity demand data employed in this study is taken from the Residential Customer Survey (RCS) of consumers conducted by the Barbados Light and Power in 1997 as part of a larger study. The survey collects information on the electricity consumed by the particular household, their portfolio of appliance holdings along with demographic information. It provides information on 129 Barbadian households, which is less than 0.2 percent of households on the island. It is a nationally representative probability sample of households, with representative sub samples among usage levels. The survey was conducted by in-home interview. Interviewers inventory the household's appliances, assess physical characteristics of the residence, and collect demographic information. To minimize measurement error, each household's metered energy consumption data are sourced directly from the electric utility. Approximately one hundred and thirty-three interviews were completed among residential customers, thus representing a response rate of 97 per cent.

The variable descriptions are provided in Table 1. The consumption of electricity, , is approximated by the monthly electricity usage. Two price variables are employed in the study: the average price of electricity and the marginal price of electricity. The average price is obtained by dividing the consumer's monthly bill in Barbados dollars by the amount of electricity (kWh) used, while the marginal price is the highest per kWh tier price that the consumer presently pays. Income is approximated by an interval variable ranging from 1, where the household's monthly income is less than BDS$1,200 to 5, if the household's income exceeds BDS $10,000 on a monthly basis. In terms of other household characteristics, variables representing the number of persons and bedrooms in the household are employed as well as the type of housing unit. The appliance portfolio is made up of dummy variables for the existence of televisions, refrigerator, washing machine, dryer, freezer, electric stove, toaster oven, wall fan, and security lighting.

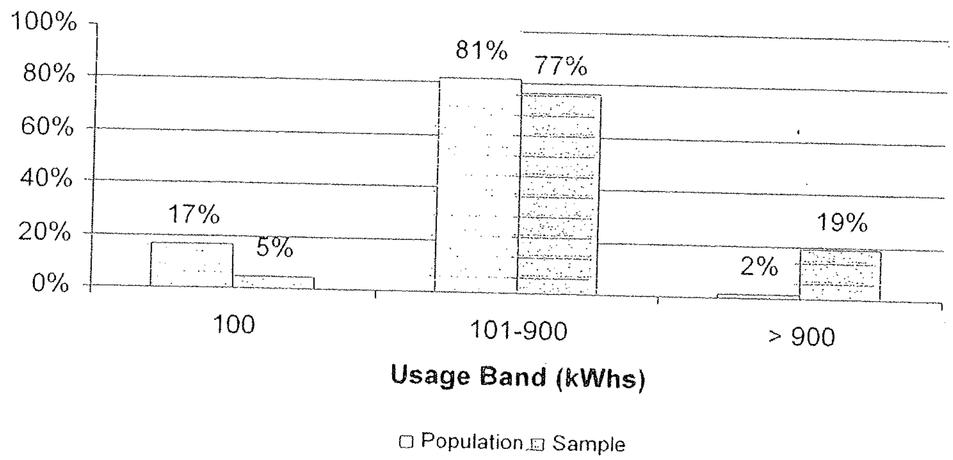
Table 1: Description of Variables

Mnemonic	Description	Scale
MONKWH	Monthly electricity usage of households	kWh
P	Average price of electricity (monthly electricity bill/monthly electricity usage)	Barbados Dollars
MP	Marginal price of electricity	Barbados dollars
INCOME	Monthly Income of household	1 = under $1200; 2 = $1200 - $2399; 3 = $2400-$4399; 4=$4400-$6399; 5=$6400-$10000;6=more than $10000
NTEL	Number of televisions	Scalar
PERSONS	Number of persons in household	Scalar
BEDROOMS	Number of bedrooms in residence	Scalar
FRIGE	Household has a refrigerator	1 if household has a refrigerator and 0 otherwise

WASHING	Household has a washing machine	1 if household has a washing machine and 0 otherwise
DRYER	Household has a dryer	1 if household has a dryer and 0 otherwise
FREEZER	Household has a freezer	1 if household has a freezer and 0 otherwise
ELESTOVE	Household has an electric stove	1 if household has an electric stove and 0 otherwise
TOASTERO	Household has a toaster oven	1 if household has a toaster oven and 0 otherwise
WALLFAN	Household has a wall fan	1 if household has a wall fan and 0 otherwise
MULUNT	Household is a multi-unit property	1 if household is a multi-unit property and 0 otherwise
SELIGHT	Household has security lighting	1 if household has security lighting and 0 otherwise
ELECHEAT	Household uses electric water heating	1 if household uses electric water heating and 0 otherwise
AC	Household has air conditioning	1 if household has air conditioning units installed and 0 otherwise
SOLAR	Household has solar water heating	1 if household has a solar water heater installed and 0 otherwise

Figure 3 provides an indication of the distribution of electricity usage in Barbados and within the sample. On the whole, most consumers (over 70 percent), tend to consume 100 – 900 kWh on a monthly basis and therefore fall in tier 2 of the BL & P three-tier price schedule. Of the remainder, just fewer than 20 percent consume more than 900 kWh on a monthly basis while a relatively small proportion of Barbadian households (below 10 percent) consume less than 100 kWh of electricity on a monthly basis.

Figure 2: Comparative Proportion of Customers by Usage



Descriptive statistics for the variables employed in the study are shown in Table 2. They suggest that the average Barbadian household uses about 546 kWh of electricity per month which translates to about BDS$105, or about BDS$0.19 per kWh. The average household sampled had a monthly income of BDS$4,400, lived in three-bedroom house with three individuals in the household.

Table 2: Descriptive Statistics

	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
MONKWH	546.426	2636.000	54.000	449.038	1.749	6.889	147.076*
P	0.190	0.210	0.180	0.006	0.703	5.136	35.139*
MP	0.203	0.220	0.180	0.009	0.484	3.980	10.199*
INCOME	3.124	6.000	0.000	1.541	0.241	2.370	3.386
NTEL	1.085	5.000	0.000	1.250	0.681	2.483	11.417*
PERSONS	3.271	6.000	0.000	1.638	0.319	2.224	5.423
BEDROOMS	3.085	6.000	0.000	1.125	-0.036	4.195	7.707*
FRIGE	0.977	1.000	0.000	0.151	-6.326	41.024	8631.741*
WASHING	0.853	1.000	0.000	0.356	-1.991	4.962	105.882*
DRYER	0.147	1.000	0.000	0.356	1.991	4.962	105.882*
FREEZER	0.488	1.000	0.000	0.502	0.047	1.002	21.500*
ELESTOVE	0.318	1.000	0.000	0.467	0.782	1.612	23.515*
TOASTERO	0.411	1.000	0.000	0.494	0.362	1.131	21.593*
WALLFAN	0.690	1.000	0.000	0.464	-0.821	1.674	23.945*
MULUNT	0.093	1.000	0.000	0.292	2.802	8.853	352.937*
SELIGHT	0.178	1.000	0.000	0.384	1.681	3.826	64.416*
ELECHEAT	0.186	1.000	0.000	0.391	1.614	3.604	57.935*
AC	0.248	1.000	0.000	0.434	1.167	2.361	31.458*
SOLAR	0.318	1.000	0.000	0.467	0.782	1.612	23.515*

5. Results

5.1 Electricity Demand Function

Table 3 displays the estimated electricity demand function for Barbados using the Heckman two-step procedure, where the Mills ratios are omitted because their economic interpretation is unclear. The second stage of the Heckman estimator was estimated using ordinary least squares (OLS) as well as full information maximum likelihood techniques. However, the results from both techniques were quite similar. Consequently, only the findings from the OLS estimation approach are displayed, with the reported standard errors being White heteroskedasticity-consistent standard errors. The model is able to account for a large proportion of the cross-sectional variation in electricity consumption, 85 percent. The calculated Jarque-Bera statistic for the model residuals suggested that the null hypothesis of normality could not be rejected at normal levels of testing.

Given that the model is a reasonably adequate representation of electricity demand in Barbados, an analysis of the estimated coefficient estimates is now given. The coefficient estimates on the appliance holdings show the proportional change in electricity consumption based on consumers' portfolio holdings (washing and elestove). The other appliances were statistically insignificant and therefore dropped out with the use of stepwise least squares. The coefficient for the existence of a washing machine was positive and statistically significant, suggesting that the presence of a washing machine is noteworthy in explaining the demand for electricity in Barbadian households.

It was somewhat surprising that the number of bedrooms had a significant positive effect on the demand for electricity while the size of the household effect was insignificant. One would have expected that household size would have a positive coefficient as larger families would consume more electricity, as well as utilise more electricity to light and cool or heat the rooms in the house depending on the seasonal requirement. Halvorsen (1975) however notes that households with larger numbers may substitute electrical power consumption with the use of natural gas for certain requirements that would be energy intensive. Leth-Peterson (2001) found evidence of such substitution for Danish households.

Table 3: Electricity Demand Model Coefficient Estimates – Heckman Two-Step Approach

Explanatory Variable	Baseline Use	Interaction Effects		
		Electric Water Heating	Solar Water Heating	Air conditioning
Constant	1.914 (5.113)	-175.589 (33.224)***	9.007 (4.157)**	-9.564 (4.015)**
p	-0.183 (0.0366)***	-1.272 (0.237)***	-	-
mp	0.061 (0.019)***	-0.473 (0.092)***	0.055 (0.025)**	-0.057 (0.024)**
income	0.029 (0.042)	-	-0.105 (0.064)*	0.135 (0.057)**
bedrooms	0.099 (0.034)***	-0.145** (0.061)	-	-
washing	0.259 (0.112)**	-	-	-
elestove	0.085 (0.076)	-	-	-
mulunt	-0.243 (0.226)	-	-	-
persons	-	-	0.086 (0.046)*	-
R-squared	0.853			
s.e.	0.335			
Jarque-Bera	0.207 [0.901]			

Notes: (1) White heteroskedasticity-consistent standard errors provided in parentheses, while p-values are given in parentheses.

(2) ***, ** and * indicates significance at the 1, 5 and 10 percent levels of significance.

Due to the existence of non-linear pricing, the coefficients on the marginal and average price as well as income variables cannot be interpreted as elasticities. As a result, following Reiss and White (2005) the non-linear price elasticity which accounts for the substitution and income effects is estimated using the following equation:

[illegible] (6)

The calculated price and income elasticities are provided for all households as well as those with electric water heating, air conditioning and solar water heating (Table 4). The computed price elasticity of demand for Barbadian households was -0.778, which is somewhat lower than that obtained by Houthakker (1951), but in line with studies which also use less aggregated data (Parti and Parti, 1980; Dubin and McFadden, 1984; Munley et al, 1990; Maddock et al, 1992). For electric water heating, the price elasticity of demand fell to -0.756, suggesting that these households tend to be less price sensitive relative to the average Barbadian household. In contrast, households with solar water heaters were more price sensitive, which might be explained by the fact that these households substitute the electricity demanding water heaters, for the heater that had no reliance on electricity. The price elasticity of households with air conditioning was generally consistent with those obtained for the average household.

Table 4: Price and Income Elasticities for Barbadian Households

Explanatory Variable	Price Elasticity	Income Elasticity
All households	-0.778	0.015
Electric water heating households	-0.756	-
Air conditioning households	-0.775	0.031
Solar water heating households	-0.783	-0.002

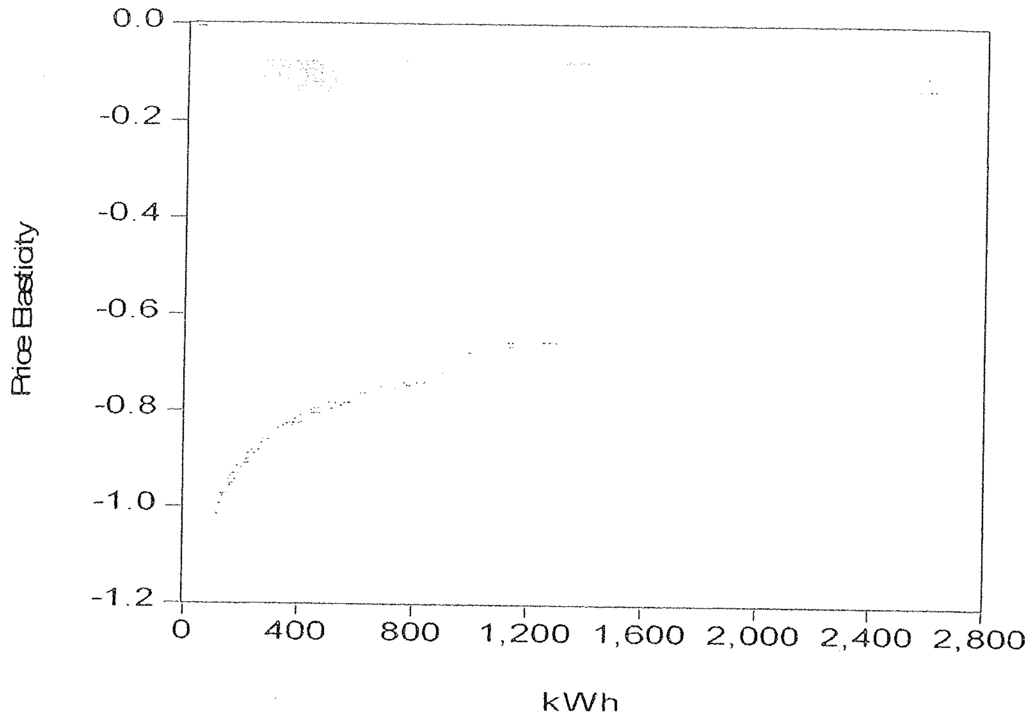
The income elasticity of demand was calculated in a similar fashion as the price elasticities. The income elasticities estimates were small, suggesting that the demand for electricity is relatively income inelastic. As noted earlier, electricity demand is a derived demand that is based on the household's portfolio of appliances. Therefore fluctuations in demand for electricity seem to be more a function of appliance holdings rather than income fluctuations. These results are similar to those obtained by Reiss and White (2005). Note that the income elasticity for households with solar water heating was negative reflecting the substitution effect arising from the use of solar power to provide water heating.

Table 5: Price and Income Elasticities by Household Income Level

Explanatory Variable	Price	Income
By household income level		
Under $1200	-0.725	0.004
$1200 - $2399	-0.852	0.010
$2400 - $4399	-0.805	0.015
$4400 - $6399	-0.788	0.019
$6400 - $10000	-0.727	0.022
More than $10000	-0.705	0.026

Table 5 disaggregates these price and income elasticites by household income level to further investigate the potential effect of income on household use of electricity. How elasticities vary by household income is of interest given that one of the objectives of the proposed rate adjustment was to lessen the impact of a rate increase on low income households. In general, the results suggest that middle-income households tend to be more price sensitive, even relative to low income households. This finding is somewhat surprising, given that low-income households should be expected to make greater adjustments to electricity consumption in order to offset the income effect of changes in the price of electricity, and may reflect the difference in appliance holdings of the two household groups. The relatively low-income households may have a portfolio of appliances that represents the necessities relative to middle-income households. As a result, relatively low-income households may be less price sensitive, since there is little they can do to adjust their electricity consumption. In contrast, the middle-income households may be able to reduce their usage of discretionary appliances. Table 5 also disaggregates the income elasticity by income group, but there was relatively little difference in the income elasticity estimates.

Figure 3: Price Elasticity of Demand by Monthly Consumption Level



An assessment of the price elasticity of demand for electricity based on the intensity of electricity use for Barbadian households is depicted in Figure 3 above. As should be expected, the price elasticity of demand falls with the intensity of electricity usage. Indeed, the price elasticity of demand for relatively low use customers is almost twice that of consumers utilising more than 1000 kWh in electricity per month.

5.2 Projected Impact of Rates Adjustment on Households

The paper now turns to investigating the impact of the proposed new rate structure on households demand for electricity. Table 6 demonstrates that the proposed changes in the electricity rates would result in a reduction in the mean marginal price of electricity. Figure 1 shows that the proposed new price schedule lays below and above the existing price schedule depending on the consumption level. The proposed four-tier system of prices will see the marginal price of electricity for households within the sample move from $0.198 per kWh to $0.184 per kWh, a decrease of 7%. Consumers that have consumption patterns under 500 kWh per month and between 1000 and 1500 kWh per month would benefit most from the changes in the marginal prices. Households however, with consumption patterns in excess of 1500 kWh and between 500 and 1000 kWh per month will face a higher marginal price.

Table 6: Marginal and Average Prices Before and After Rate Adjustments

Household monthly Consumption	Existing Average Price	Proposed Average Price	*Percentage Change*	Existing Marginal Price	Proposed Marginal Price	*Percentage Change*
Under 500 kWh	0.462	0.495	7.1	0.195	0.174	-10.5
500 to 1000 kWh	0.458	0.486	6.1	0.196	0.200	2.0
1000 to 1500 kWh	0.460	0.486	5.6	0.216	0.200	-7.4
More than 1500 kWh	0.467	0.492	5.5	0.216	0.224	3.7
Sample	**0.461**	**0.492**	**6.7**	**0.198**	**0.184**	**-7.0**

Table 7 further suggests that the proposed changes in the rate structure will result in an expansion in the average price of electricity for households at all consumption levels. This finding occurs because of the proposed increase in the monthly customer charge and the shifting of the fuel related $0.0264 from the base charge to the FCA.

Table 7: Distributional kWh Monthly Impact of Rate Adjustments

	Average Price Effect	Marginal Price Effect	Total Effect
	Monthly Household Income		
Under $1200	-15 (-5.7%)	21 (7.3%)	6 (1.6%
$1200 - $2399	-19 (-6.3%)	19 (8.1%)	0 (0.0%)
$2400 - $4399	-22 (-5.5%)	21 (5.9%)	-1 (-0.4%)
$4400 - $6399	-26 (-4.6%)	22 (4.8%)	-4 (-0.2%)
$6400 - $10000	-36 (-4.1%)	22 (3.5%)	-14 (-0.6%)
More than $10000	-40 (-4.0%)	10 (1.1%)	-30 (-3.0%)
	Monthly Consumption Band		
Under 500 kWh	-15 (-5.8%)	24 (8.4%)	9 (2.6%)
500 to 1000 kWh	-33 (-4.6%)	-11 (-1.5%)	-44 (-6.2%)
1000 to 1500 kWh	-44 (-3.7%)	58 (4.9%)	14 (1.2%)
More than 1500 kWh	-70 (-3.3%	-47 (-2.3%)	-117 (-5.6%
Sample	**-24 (-5.2%)**	**19 (5.5%)**	**-5 (0.0%)**

Note: percentage changes given parentheses below values

The results from the simulation exercises to examine the impact of the proposed rates on household electricity consumption are shown in Table 7. Households will generally alter their electricity consumption very little in response to the proposed changes to the four-tier structure and the increase in price. The findings indicate that the average monthly electricity consumption within the sample will be 5 kWh lower due to marginal price changes offsetting much of the effect of the average price increases. The model predicts that notable reductions in demand will only occur within upper income households. This is confirmed by the 5.6% decrease in demand projected for households consuming over 1500 kWh per month as households with these consumption levels are normally within the upper income bracket. Households with monthly consumption patterns between 500 kWh and 1000 kWh per month are expected to make the greater percentage adjustment in their demand for electricity. These households are likely to contract their monthly consumption by 6.2%.

The BL & P indicated that the proposed rate structure is designed to achieve a number of objectives. Evaluating how the proposed new pricing structure will meet those objectives is not very simple; however some inferences can be made from the results. The structure of the new pricing system seem likely to reach its primary objective of raising additional revenue as demonstrated by the across the board increase in the average price. The success of the secondary objective of minimizing the price impact on the lower income households is also evident. Low income households within the sample consume less than 500 kWh per month and therefore will benefit from a significant reduction in their marginal price. The objective of encouraging households to use electricity more efficiently and thus promote energy conservation will also likely be accomplished. The rise in marginal prices for higher levels of consumption will have the effect of lowering significantly the demand for electricity among households within the high and middle consumption bands.

6. Conclusions

With a review of the rates and rate structure of the Barbados Light and Power Company forthcoming, this paper estimated, for the first time, an electricity demand function using survey data of a sample of 130 Barbadian customers. This function is then employed to project the impact of the proposed change in the rates and rate structure on Barbadian households. As the demand for electricity services is a derived demand and data for the electricity demand for individual appliances is not available, electricity demand is modelled as the sum of the electricity used by appliance categories. Following Dubin and McFadden (1984), the choice of space cooling and water heating are isolated in this paper, while the other appliances are treated as statistically exogenous. The non-linear pricing structure in Barbados is set up as a censored regression and estimated utilising the Heckman two-step approach where, due to the existence of non-linear pricing, Reiss and White (2002) coefficients on the marginal and average price as well as income variables are computed.

The reported results suggest that the price elasticities of demand for particular appliances varied significantly, with households with solar water heating more price elastic than those with air conditioning and electric water heating. The income effects were, however, statistically insignificant as these effects may have been captured by choices of appliances rather than utilisation and agree with studies by Parti and Parti (1980) and Dubin and McFadden (1984). The income elasticity for households with solar water heating was found to be negative, probably reflecting the substitution effect arising from the use of solar power to provide water heating. The database also allowed the authors to breakdown price and income elasticities by individual households and these results suggest that middle-income households tend to be more prices sensitive, even relative to low income households, indicating that the middle-income households may be more able to reduce their usage of discretionary appliances.

The impact of the introduction of the new tariff structure was also analysed and revealed that households with consumption patterns under 500 kWh will fear much better than higher consumption households. In general households will vary their consumption very little as a result of the introduction of the new rate structure. The more significant reduction in the demand for electricity is expected among upper income and upper consumption households.

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Energy Consumption and Economic Growth in Latin America and the Caribbean: A Panel Cointegration Approach

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1. Introduction

Since the seminal study by Kraft and Kraft (1978) on the United States (US) economy, the causal relationship between energy consumption and economic growth has been undertaken for a wide range of countries. An investigation of the energy consumption–growth nexus not only provides insights with respect to the role of energy consumption in economic development, but also provides a basis for discussion of energy policies. For example, if energy consumption is a vital component in economic growth either directly or as a complement to other factors of production, energy conservation policies that reduce energy consumption may have an adverse impact on a country's growth prospects. Alternatively, if energy consumption is largely dependent on economic growth, energy conservation policies oriented towards the reduction in energy consumption may not have an adverse impact on a country's growth prospects. Indeed, as one might expect, the empirical literature on the energy consumption–growth nexus have yielded mixed results. As pointed out by Yu and Choi (1985), Ferguson et al. (2000), and Toman and Jemelkova (2003), the absence of any clear consensus on the relationship between energy consumption and growth can be attributed to the heterogeneity in climate conditions, varying energy consumption patterns, the structure and stages of economic development within a country, the alternative econometric methodologies employed, the presence of omitted variable bias along with varying time horizons of the studies conducted.

This study aims to extend the empirical literature on the causal relationship between energy consumption and economic growth in the case of Latin America and the Caribbean (LAC), a region not yet examined in the literature to the best knowledge of the authors. A neo-classical one-sector aggregate production model advanced by Ghali and El-Sakka (2004), Soytas and Sari could be attributed to either excessive energy consumption in unproductive sectors of the economy, capacity constraints, or an inefficient energy supply (Squalli, 2007).

The conservation hypothesis asserts that energy conservation policies designed to reduce energy consumption and waste will not adversely impact real GDP. This hypothesis is supported if an increase in real GDP causes an increase in energy consumption. However, it is possible that a growing economy constrained by political, infrastructural, or mismanagement of resources could generate inefficiencies and the reduction in the demand for goods and services, including energy consumption (Squalli, 2007). If such is the case, an increase in economic growth would have an adverse impact on energy consumption.

The neutrality hypothesis considers energy consumption to be a small component of overall output and thus have little or no impact on real GDP. Similar to the conservation hypothesis, energy conservation policies would not adversely impact real GDP. Support for this hypothesis occurs if there is the absence of a causal relationship between energy consumption and real GDP.

Finally, the feedback hypothesis suggests that energy consumption and real GDP are interrelated and may very well serve as complements to each other. The feedback hypothesis suggests there is a bidirectional causal relationship between energy consumption and real GDP. If this is the case an energy policy oriented toward improvements in energy consumption efficiency would not adversely affect real GDP.

Francis et al. (2007) find evidence of bi-directional causality between real GDP per capita and energy consumption for Haiti, Jamaica and Trinidad and Tobago from 1971-2002 using a Bayesian VAR. Huang et al. (2008) provide support for the neutrality hypothesis for the low income panel while the conservation hypothesis for the middle income panel.

With the exception of the Huang et al. (2008) study, the studies pertaining to LAC countries have evaluated the relationship between energy consumption and economic growth within a bivariate framework. However, a common problem of bivariate analysis is the possibility of omitted variable bias (Lütkepohl, 1982). Recognising the omitted variable problem, this study examines the relationship between energy consumption and economic growth within a multivariate framework by including measures of capital and labour *a la* Ghali and El-Sakka (2004), Soytas and Sari (2007), Yuan et al. (2008) and Apergia and Payne (2009). Second, unlike many of the previous studies on energy consumption and economic growth, the sign and magnitude of the respective coefficients will be discussed in relation to the various hypotheses on the energy consumption–growth nexus. Third, in response to the short data span and the reduction in the power and size properties of conventional unit root and cointegration tests, the panel unit root and cointegration testing approach advanced by Pedroni (1999, 2004) will be employed.

Panel unit root and cointegration tests provide additional power by combining the cross-section and time series data allowing for the heterogeneity across countries. This approach has many advantages over the traditional panel models. First, the cointegration tests are more powerful and allow us to increase the amount of information coming from the cross-sectional data. This means that they have the ability to estimate the long-run equilibrium relationship that links the

At present, electricity generation in Latin America is dominated by large hydro, natural gas, and fossil fuels (oil and diesel). By comparison, in the Caribbean, almost all electricity generation comes from imported oil and diesel. At least 50 million people, or 13 percent of the population of LAC, remain without access to electricity, with 20-90 percent of the rural population lacking access to electricity depending on the country (OAS, 2007). Electricity markets in Latin America have some degree of competition and are generally separated between generation, transmission and distribution. These markets engage independent power producers (IPPs), with power purchase agreements (PPAs), and bulk market agreements. Markets in the Caribbean consist of vertical monopolies and policies that ensure a set rate of return for electric companies. There are also various types of interconnection and cooperation measures among countries, including interconnection of electricity networks and grids, as is the case of the Electricity Interconnection System for the Central American Countries (SIEPAC). Fuel supply interconnections include gas pipelines, such as those that span Bolivia, Brazil, and Argentina and PetroCaribe's 'virtual' fuel interconnection.

The top three consumers of oil in the region from 2000-2007 were: Brazil (2,193,000 bpd); Mexico (2,026,000 bpd); and Venezuela (581,000 bpd). On the other end of the spectrum were: Montserrat (440 bpd); Falkland Islands (220 bpd); and Turks and Caicos Islands (90 bpd). With respect to oil production, there are very few producers. Large-scale producers over this period were: Mexico (3,359,000 bpd); Venezuela (2,937,000 bpd); Brazil (1,880,000 bpd); Argentina (831,000 bpd); Colombia (582,000 bpd); Ecuador (465,000 bpd); Trinidad and Tobago (164,000 bpd); and Peru (102,000 bpd). Small scale producers were: Bolivia (53,000 bpd); Cuba (51,000 bpd); Guatemala (19,000 bpd); US Virgin Islands (16,000 bpd); Chile (15,000 bpd); Suriname three consumers are: Brazil (23.6 million short tonnes); Mexico (17.9 million short tonnes); and Chile (5.4 million short tonnes).[5]

With respect to renewable energy sources, very few LAC countries produce or consume biofuels. Brazil is, by a considerable margin, the largest producer and consumer. From 2000-2007, Brazil produced 247,000 barrels of ethanol per day, while consuming 208,000 bpd. No other country in LAC produces more than 2,350 bpd (Jamaica), or consumes more than 1,200 bpd (Colombia). Biodiesel production and consumption is low. Argentina leads the way in production at 1,150 barrels per day and in consumption at 360 barrels per day. Brazil is also the largest producer and consumer of renewable electricity (hydro power, and non-hydro sources such as geothermal, wind, solar and waste) at 330 billion kWh a year respectively.[6]

The previous overview of the LAC region's level of economic development and composition of energy production and usage serves as a useful point of reference to examine the causal relationship between energy consumption and economic growth in the case of LAC. It also highlights the large variation in the energy consumption mix of countries in the region.

4. Data and Methodology

4.1 *Empirical Framework*

To investigate the relationship between energy use and output growth, we use the framework outlined in Ghali and El-Sakka (2004), Soytas and Sari (2007) and Yuan et al. (2008) based on

[5] See footnote 2. Figures are annual averages.
[6] See footnote 2.

4.2 *Panel Unit Root Tests*

Panel unit root tests are similar, but not identical to unit root tests carried out on a single series. The literature suggests that a panel-based unit root test enhances the power of the unit root test as it allows for greater efficiency by providing more degrees of freedom and for heterogeneity across individual series. Consider the following autoregressive specification:

$$y_{it} = \rho_i y_{it-1} + \delta_i X_{it} + \varepsilon_{it} \tag{3}$$

where $i = 1, 2 \ldots, N$ cross-sectional units observed over periods $t = 1, 2 \ldots, T$; and X_{it} represent the exogenous variables in the model including any fixed effects or individual trends; ρ_i are the autoregressive coefficients, and the errors ε_{it} are assumed to be independent of idiosyncratic disturbance; if $|\rho_i| < 1$, y_i is said to be weakly (trend) stationary. On the other hand, if $|\rho_i| = 1$, then y_i contains a unit root.

Levin, Lin and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003), Fisher-type tests using ADF and PP tests (Maddala and Wu (1999), and Choi (2001)), and Hadri (2000) have explored various methodologies in estimating panel unit roots. Theoretically, they are simply multiple-series unit root tests that have been applied to panel data structures. In testing, there are two natural assumptions that can be made about the ρ_i. The first one may assume that the persistence parameters are common across cross-sections so that $\rho_i = \rho$ for all i. The Levin, Lin, and Chu (LLC), Breitung, and Hadri tests all employ this assumption. Alternatively, one can allow ρ_i to differ across individual cross-sections. The Im, Pesaran, and Shin (IPS), and Fisher-ADF and Fisher-PP tests are of this form.

(that is, group mean panel cointegration statistics) which includes three statistics: group ρ-statistic, group PP-statistic, and group ADF-statistic. These statistics are based on averages of the individual autoregressive coefficients associated with the unit root tests of the residuals for each country in the panel. All seven tests are distributed asymptotically as standard normal. Of the seven tests, the panel ν-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration.

4.4 *Panel Causality Tests*

Once these variables are cointegrated, the next step is to implement the causality test. We therefore use a panel-based VECM to identify the nature of the long-run equilibrium relationship using the two-step procedure of Engle and Granger (1987). In the first step, we estimate the long-run model for Equation (4) in order to obtain the estimated residual □ (the error correction term; ECT hereafter). In the second step, we estimate the panel Granger-causality model with dynamic error correction as follows:

$$\Delta Y_{it} = \theta_{1j} + \lambda_{1i} ECT_{it-1} + \sum_k \theta_{11ik} \Delta Y_{it-k} + \sum_k \theta_{12ik} \Delta EC_{it-k} + \sum_k \theta_{13ik} \Delta K_{it-k} + \sum_k \theta_{14ik} \Delta L_{it-k} + u_{1it} \quad (6a)$$

$$\Delta EC_{it} = \theta_{2j} + \lambda_{2i} ECT_{it-1} + \sum_k \theta_{21ik} \Delta Y_{it-k} + \sum_k \theta_{22ik} \Delta EC_{it-k} + \sum_k \theta_{23ik} \Delta K_{it-k} + \sum_k \theta_{24ik} \Delta L_{it-k} + u_{2it} \quad (6b)$$

$$\Delta K_{it} = \theta_{3j} + \lambda_{3i} ECT_{it-1} + \sum_k \theta_{31ik} \Delta Y_{it-k} + \sum_k \theta_{32ik} \Delta EC_{it-k} + \sum_k \theta_{33ik} \Delta K_{it-k} + \sum_k \theta_{34ik} \Delta L_{it-k} + u_{3it} \quad (6c)$$

$$\Delta L_{it} = \theta_{4j} + \lambda_{4i} ECT_{it-1} + \sum_k \theta_{41ik} \Delta Y_{it-k} + \sum_k \theta_{42ik} \Delta EC_{it-k} + \sum_k \theta_{43ik} \Delta K_{it-k} + \sum_k \theta_{44ik} \Delta L_{it-k} + u_{4it} \quad (6d)$$

consumption per capita, respectively.[7] Real GDP per capita (in US$), the real capital stock per capita (LCU) and the labour force are proxied by series taken from the World Bank *World Development Indicators* CD-ROM 2007. The implicit GDP deflator, also taken from WDI, and nominal exchange rates, taken from the International Monetary Fund *International Financial Statistics* CD-ROM 2008, are used to convert nominal gross capital formation in local currency units into its real form denominated in US dollars. The labour force is proxied by the population between 15-64 years of age. Total primary energy consumption per capita (in millions of Btus) is sourced from the Energy Information Administration available online at: http://www.eia.doe.gov. All series are converted into natural logarithms for estimation purposes.

5. Empirical Results and Analysis

The twenty-three LAC countries under study are presented in Table 1. Within this group, countries are grouped into the categories, net energy exporters, net energy importers, Latin America countries, and Caribbean countries respectively.[8] Table 2 presents average annual growth rates for real GDP per capita, energy consumption per capita, capital stock per capita and the labour force over 1980-2004. Chile's economy grew the fastest, followed by St. Lucia's and St. Vincent and the Grenadines', while Paraguay, Honduras and Belize recorded the highest rates of growth in energy consumption. Panama is the only country whose economy grew at a faster rate than did its energy consumption. Interestingly, net energy exporters as a whole have both a lower rate of economic growth and higher growth rate of energy consumption compared to net

[7] We use per capita magnitudes in this article for two reasons (Lanne and Liski, 2004). First, per capita values are less sensitive to territorial changes. Second, per capita numbers provide the variables in the same units for large and small countries; that is, they control the scale of the economy. Moreover, we follow the previous literature in the setting of per capita variables, including Beaudreau (1995, 1998), Nourzad (2000), Yoo (2006), and Mehrara (2007).
[8] Determination of whether a country is a net exporter or net importer of energy was based on the difference between average production and average consumption of total primary energy over 2000-2006.

Caribbean) find scant evidence of a long-run relationship. Accordingly, all further analysis is conducted on the entire sample of 23 countries.

Elasticities of production are important for understanding the effect of marginal changes in the production factors on output. Table 5 presents the results using OLS estimation for the cointegrated panels. First, all variables have a positive sign and are statistically significant, implying that more of each input results in greater output, all other things constant, consistent with growth theory. Compared to the results of other estimates using panel data, the elasticity of real GDP with respect to energy usage (0.083 percent) is lower than the 0.50 percent reported by Lee (2005) for 18 developing countries, the 0.32 percent reported by Lee and Chang (2008) for 16 Asian countries, the 0.25 percent reported by Lee et al. (2008) for 22 OECD countries and the 0.12 percent reported by Narayan and Smyth (2008) for G7 countries. Moreover, the elasticity of energy usage is greater than the elasticity of capital which parallels the results found by Lee (2005) and Lee and Chang (2008); however, in the case of Lee et al. (2008) and Narayan and Smyth (2008), the elasticity of capital is greater than the elasticity of energy usage. Second, although the elasticity of energy consumption is greater than the elasticity of capital, when each input is doubled, output increases in both cases by roughly 8 percent. Third, the impact of labour on real GDP is over 7 times greater than the effects of both energy consumption and capital. This result is consistent with our earlier discussion that LAC countries were for the most part previously driven by their labour-intensive agricultural sectors; even tourism to which many LAC countries have turned is also labour-intensive. Fourth, if energy, capital and labour are the only inputs into the production process as suggested by our empirical framework, then the production process in LAC exhibits decreasing returns to scale.

general, an increase in GDP would affect energy consumption in two ways. First, households can chose to spend the extra income earned on energy-intensive activities such as computers, better household appliances or transport. Second, economic growth would expand activities and energy is an important input in the production process for countries that are seeking to reposition their economies, like in LAC where there countries are transitioning away from activities such as agriculture. On the other hand, the need for the energy input is especially relevant in energy exporting countries as they are energy-intensive users in the extraction and production of energy. Hence, energy consumption increases and this in turn increases value added to GDP by way of output and exports. Finally, this bi-directional result suggests that energy policies oriented toward improvements in energy consumption efficiency in LAC countries would not adversely affect real GDP.

There is also a bi-directional causal relationship the capital stock and output (since ΔK is significant in Equation (6a) and ΔY is significant in Equation (6c)) meaning that the two variables mutually reinforce each other. Overall, the indication is that the efforts of policymakers should be directed towards building and nurturing an investment climate which attracts more capital, which can lead to economic growth and. by extension, can lead to increasing efficiency in the use of energy.

Policies for energy efficiency should also be long-term in nature and encourage proper market and pricing signals. Legal and institutional frameworks need to be supportive and remove market distortions that favour conventional sources. Regulatory interventions are required to implement norms; monitoring and enforcement is appropriate in this instance. Policies must also increase in labour force increases output by 0.586 percent. The short run results also indicate the importance of energy consumption to economic growth and vice-versa.

We argue that policies for energy efficiency should be long-term in nature and should encourage proper market and pricing signals. However, while it is difficult to be definitive about energy policy, it must be acknowledged that such a discussion needs a holistic setting to be more effective and not just based on the empirical evidence on causality between energy consumption and economic growth.

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Table 2: Average Growth Rates 1980-2004 (%)

	GDP	Energy Consumption	Capital Stock	Labour Force
Argentina	0.17	2.31	1.92	1.45
Belize	2.75	8.19	6.39	3.52
Bolivia	-0.09	4.68	2.01	2.42
Brazil	0.43	3.46	79.84	2.29
Chile	3.39	4.52	6.99	1.94
Colombia	1.12	2.48	4.07	2.49
Dominican Republic	2.03	5.11	4.54	2.46
Ecuador	0.44	3.24	4.40	2.75
El Salvador	0.50	4.10	3.62	2.25
Guatemala	0.12	4.45	4.42	2.37
Guyana	0.98	1.02	1.77	0.64
Honduras	0.10	8.72	5.26	3.37
Jamaica	1.34	1.61	5.98	1.49
Mexico	0.77	2.41	2.17	2.64
Nicaragua	-0.76	3.24	43.54	2.72
Panama	1.30	1.05	8.14	2.64
Paraguay	-0.26	14.18	1.11	3.01
Peru	0.14	1.60	2.51	2.55
St. Lucia	3.25	5.91	3.85	2.33
St. Vincent & The Grenadines	3.18	6.98	4.21	1.65
Suriname	0.18	0.78	6.41	1.60
Trinidad & Tobago	1.00	5.73	2.12	1.49
Venezuela	-0.80	2.68	7.85	2.82
Net Energy Exporters	0.30	4.71	3.21	2.38
Net E[illegible]	1.26	3.85	12.50 (4.93)	2.25
Latin America	0.54	4.08	11.40 (4.22)	2.51
Caribbean	[illegible]	4.32	4.39	1.82
Total	0.93	4.15	9.27 (4.27)	2.30

Note: Figures in parentheses indicate the values for the subsamples when Brazil and Nicaragua are excluded.

Table 4: Pedroni Panel Cointegration Tests

	Full Sample	Energy Exporters	Energy Importers	Latin America	Caribbean
Panel v	-2.858***	1.352	0.270	0.666	0.455
Panel ρ	0.165	1.356	0.849	0.153	1.179
Panel PP	--2.811***	1.799	-0.711	-1.851**	0.994
Panel ADF	-3.426***	1.653	0.016	-0.260	1.771
Group ρ	1.312***	1.270	1.630	1.129	2.036
Group PP	-7.077***	-0.076	-1.796	-2.605***	1.227
Group ADF	-3.178***	-0.394	-1.224	-1.863**	2.029

Note: ***, ** and * represent significance at the 1, 5, and 10 percent levels of significance respectively.

Table 6: Panel Causality Tests

Dependent Variable	Short Run				Long Run
	ΔLY	ΔEC	ΔK	ΔL	ECT
6(a): ΔY	--	0.053 (5.214)**	0.072 (103.136)***	-0.032 (0.065)	-0.292 (-3.539)***
6(b): ΔEC	0.350 (7.866)***	--	0.015 (0.934)	0.480 (1.327)	0.105 (2.342)**
6(c): ΔK	2.503 (142.843)***	0.041 (0.130)	--	-0.263 (0.080)	1.157 (3.121)***
6(d): ΔL	-0.010 (1.084)	0.003 (0.572)	0.001 (0.170)	--	0.010 (1.175)

Note: Figures in parentheses for the short run variables are (partial) Wald F-statistics. Figures in parentheses for the ECT are *t*-statistics. ***, ** and * represent significance at the 1, 5, and 10 percent levels of significance respectively.