THE ELECTRICITY TARIFF SYSTEM, CONSUMPTION AND PURCHASING PATTERNS AND ENERGY EFFICIENCY IN LOW-INCOME HOUSEHOLDS IN CAPE TOWN

Edward James-Smith & Mikael Togeby
Ea Energy Analyses, Copenhagen, Denmark

ABSTRACT

This paper utilises data provided by the Cape Town Electricity Department to make a simple statistical analysis of the tariff system and consumption and purchasing patterns in the Cape Town distribution area. The statistical analysis is used to provide suggestions for amendments to the tariff and retail system that may help alleviate energy poverty in low income households and promote energy efficiency.

1. INTRODUCTION

This paper is based on the report "Fighting Energy Poverty in Cape Town" written by the same authors in November 2007 for the City of Cape Town under the Urban Environmental Management Programme.

The information and data used in this paper was provided by the Cape Town Electricity Department and through informants from site visits to the informal settlements of Imizamo Yethu in Hout Bay, Philippi and Samora Machel in Khayelitsha.

2. ELECTRICITY TARIFFS IN CAPE TOWN

Currently two tariffs are widely used amongst households in Cape Town: 190.000 households use Domestic Tariff 1, which is for households using more than an average of 600 kWh per month, and 333.000 households uses Domestic Tariff 2, which is for households using fewer than 600 kWh per month on average. With a consumption of 600 kWh/month the two tariffs give the same total costs for the consumer.

Domestic 2 includes 50 kWh/month of free electricity for households purchasing 400 kWh or less per month. This tariff does not have a service charge, but the variable energy charge is higher than for Domestic 1. Households may choose which tariff they wish to be charged by irrespective of their consumption.

A simple Excel model was constructed to analyse different tariff designs. The current Domestic 1 and 2 were assessed, and alternative models tested and calibrated to give the same total revenue as Domestic 1 and 2 give today.

The electricity cost is calculated using the model for 95 segments of consumption at intervals of 10 kWh: 0-10 kWh/month, 10-20 kWh/month, etc. the highest interval is 940-950 kWh/month

The number of consumers in each interval was estimated using information from the database provided by the Department of Electricity.

Table 1: Consumers in each interval as used in the tariff model

	Number of users	Number of users in intervals of 10 kWh/month
0-50	13.333	2.667
50-100	17.333	3.467
100-150	20.000	4.000
150-200	24.000	4.800
200-250	26.667	5.333
250-300	26.667	5.333
300-350	26.667	5.333
350-400	26.667	5.333
400-600	151.667	7.583
600-950	190.000	5.550

The current tariffs were translated into a number of variables, as shown in table 2 below, for use on the tariff model.

Table 2: Variables for the current tariffs Domestic 1 and 2

Input	Domestic 2	Domestic 1	unit
Energy charge	48,94	36,72	c/kWh
Service charge	0	2,39	R/Day
Free electricity	50		kWh/month
End free electricity	450		kWh/month
End tariff Domestic 2	600		kWh/month

The output from the model is shown in table 3 and figure 1 below.

Table 3: Output from tariff model for existing tariff structure

Subsidy (0-600 kWh):	ZAR15,9 mil.
Revenue, energy charge	ZAR105,8 mil.
Revenue, service charge	ZAR 14,4 mil.
Total revenue	ZAR 120,2 mil

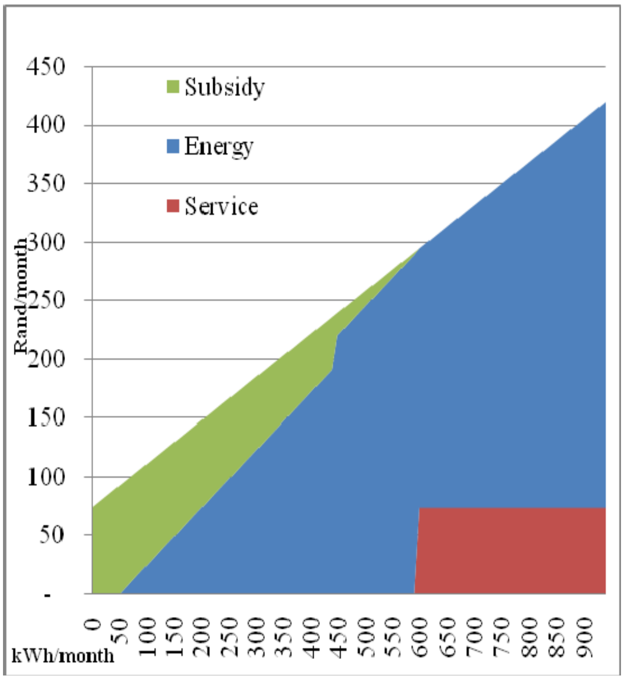

Figure1: Graph of the total income from Domestic 1 and 2

The subsidy has been calculated as the difference between Domestic 1 and 2. In this way Domestic 1 is considered as a cost reflective tariff. It should be noted that this is a (crude) assumption.

The two tariffs are generally well designed. Positive aspects are:

- Smooth costs curve
- Highest subsidy for lowest use (highest subsidy at 50 kWh/month)
- High variable cost instead of service charge in the range 50-600 kWh/month

Critical comments to the design of the tariff include:

- Zero variable cost at low interval (0-50 kWh/month): No incentive for economical behaviour
- Subsidy to relatively high demand. Subsidy ends at 600 kWh/month. Many medium income households consume electricity in this range
- Jump in costs at 400 kWh/month purchased (450 consumed). One extra kWh means loss of the free 50 kWh – a value of R24.47.
- The difference between the two tariffs may be difficult to understand for end-users. The service charge may be misunderstood as costly (if not taking the reduced variable cost for Domestic 1 into account)
- Favours one person homes and small families in all income groups

3. TWO ALTERNATIVE TARIFFS

Two alternative tariff systems were looked at in order to determine the effect these would have on low-income consumers and energy efficiency. The income for the Electricity Department and the subsidy were kept constant in order that no additional costs would be incurred for Cape Town. The two alternatives were also designed to adhere with tariff guidelines in regulation in South Africa.

The two alternatives were inspired by the feedback received from low-income consumers on their understanding of electricity tariffs. This indicated that the current block tariff system was not well understood, and that the service charge in Domestic 1caused confusion and an unwillingness to change to Domestic 1 despite consumption over 600 kWh/month.

2.1 ALTERNATIVE 1: SIMPLE TARIFF STRUCTURE

In alternative tariff 1 the two current tariffs were amalgamated into one. The service charge for consumption over 600 kWh was removed and 50 kWh free basic electricity was given to all consumers in order to keep the tariff as simple as possible. In order to maintain the same total revenue it was necessary to increase the unit price to 50,48c/kWh.

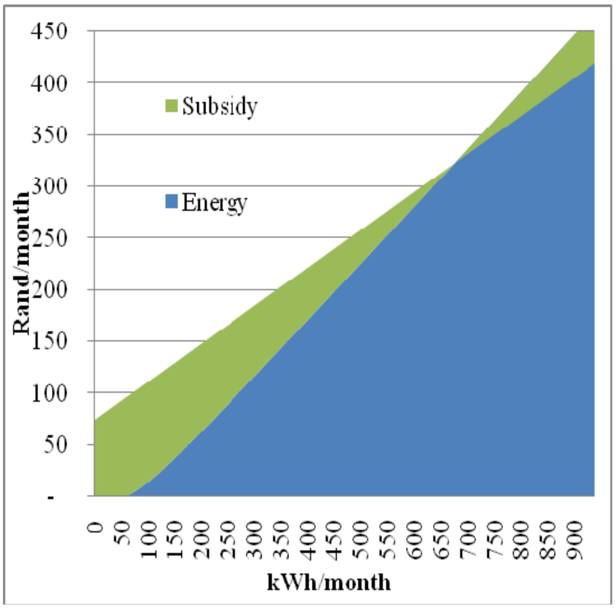

Figure 2: Alternative tariff 1

Total payment is the blue area up till 715 kWh and for higher demand it is the upper line. The green areas is a subsidy. The subsidy is received by those consuming less than 715 kWh/month, and paid by those consuming more than 715kWh/month.

Table 5: Output from model for alternative tariff 1

Subsidy	R15,8 mil.
Total revenue, energy	R120,2 mil.
Total revenue, service	-
Total revenue	R120,2 mil.

The positive factors of alternative 1 are:

- Easily understood by customers

- Easy administration
- Wider targeting ensures maximum of low income households receive benefits
- Increased marginal price (mostly for Domestic 1 users) increases incentive to save electricity

Critical comments of alternative 1 are:

- Steep increase in price after 50 kWh may result in households utilising alternative fuels
- No incentive to be economically efficient with the first 50 kWh
- Subsidy at high demand
- Favours one person homes and small families in all income groups

2.2 ALTERNATIVE 2: GRADUAL TARIFF STRUCTURE

The current Domestic 2 has a high variable price in the range 50-600 kWh/year. The high price is in exchange for the service charge. An alternative design could be to let the variable price increase smoothly from 0 to its final value. This could be modelled as shown in figure 3: An asymptotic function. To reach the same total revenue the asymptotic value is set to 55,59 c/kWh.

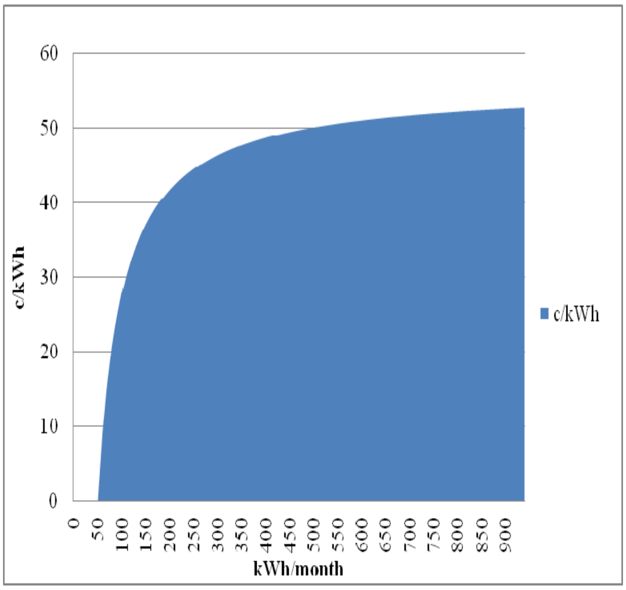

Figure 3: Alternative tariff 2 with a slow increase in the variable price

Table 5: Example of energy charge at various intervals using alternative tariff 2

Demand (kWh/month)	Energy charge (c/kWh)
0	0
50	0
100	27,8
200	41,7
400	48,6
600	51,0
800	52,1

Table 6: Output from alternative tariff 2

Subsidy	R15,8 mil
Total revenue, energy	R120,2 mil
Total revenue, service	-
Total revenue	R120,2 mil

Advantages of alternative 2 are:

- Gradual increase in price per kWh. Smooth start at 50 kWh/month and no jump 450 kWh/month
- Reduces incentive for using alternative fuels
- Encourages energy efficiency

Critical points of alternative 2:

- More complicated tariff system for customers to understand
- Increased cross subsidisation in system

2.3 COMPARISON OF THE THREE TARIFFS

Three different sets of tariffs have be analysed, all three models have the same electricity sales, all three have 50 kWh/month free electricity and all three give the same total revenue and subsidy. Table 7 below compares the differences between the tariff alternatives.

Table 7: Comparison of the three tariffs

	Current tariffs	Alternative 1	Alternative 2
Ease of computation	Yes	Yes	Yes
Easy to understand	Shift between two tariffs, at 450 kWh/m is somewhat complicated	Yes	Variable price requires a table or a graph
Fairness	Yes	Yes	Yes
Highest energy charge	50-600 kWh/m	Same charge (above 50 kWh/m)	Increasing asymptotic to highest value
Jump in payments?	Yes at 450 kWh/m	No	No
Subsidy	Yes, until 600 kWh/m, highest below 450 kWh/m	Yes, until 700 kWh/m, extra cost for users above 700 kWh/m	Yes, until 680 kWh/m, extra cost for users above 680 kWh/m
Service charge	Yes above 600 kWh/m	No	No
Legally acceptable	Yes	Yes	Yes

The graph in figure 4 compares the costs for consumers of each tariff system at different levels of consumption. The differences in total costs are moderate. For users with a high demand some difference can be seen.

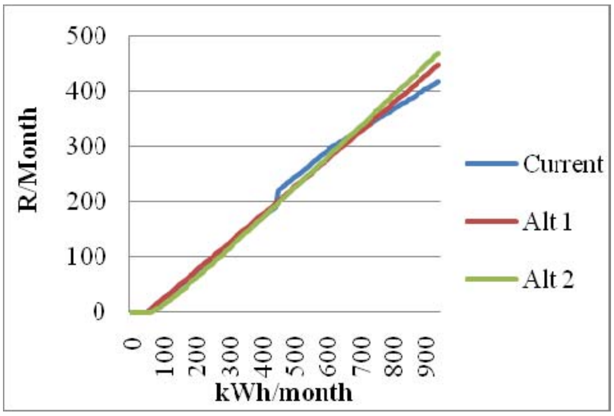

Figure 4: Comparison of costs between three tariff systems

3. ELECTRICITY CONSUMPTION AND PURCHASING PATTERNS IN CAPE TOWN

3.1 LOAD CURVE FOR CAPE TOWN AND ENERGY EFFICIENCY

The Cape Town Electricity Department provided data from which a load curve for Cape Town was calculated. The daily load curve for Cape Town is shown in figure 5 below.

The interesting points to note on the load curve are that the curve is relatively flat during the day with consumption in the middle of the morning only marginally lower than the absolute peak in the evening and that the winter peak is only 20% higher than the summer peak.

These load patterns indicate that there is a large constant consumption outside of cooking in the domestic sector and that energy efficiency initiatives may have equal or greater economic value in areas other than cooking. This could indicate that promoting alternatives to electricity for cooking in low-income households has no greater economic value than reducing consumption in water geysers and pool pumps in peak periods.

According to the data received from the Electricity Department low income households contribute less than 20% of total peak demand, which indicates that it probably is not in this group of consumers that the most economic energy savings are to be found. Energy efficiency in low income households is, however, not only about saving kWh's. Increased efficiency in this consumer group can result in improved quality of life due to receiving improved energy services for the same amount of money, thereby reducing energy poverty and making funds available for other necessities.

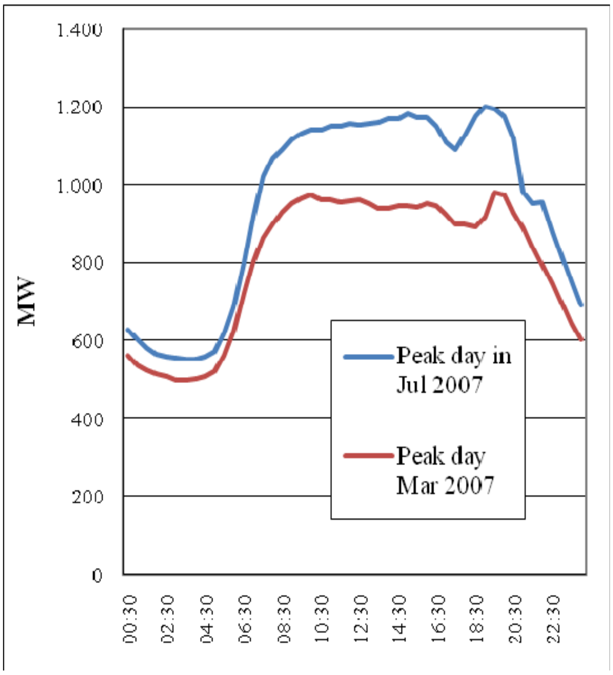

Figure 5: Load curve for Cape Town Metro. Scaled up to cover the complete supply area.

3.2 PURCHASING PATTERNS AND FREE BASIC ELECTRICITY

The Department of Electricity provided a database on purchase of electricity for users on Domestic 2 that received the 50 kWh free electricity. This covers users with consumption below 400 kWh per month. In some cases a higher monthly purchase occurs. Users with an average monthly consumption over 12 months that is below 400 kWh/month receive 50 kWh free basic electricity.

The database covers the monthly purchase of electricity for 192.468 users from October 2006 to October 2007. Information for November 2006 to October 2007 (the newest 12 month period) was used. Meters still in stock are included in the database as are meters that have been lost, e.g. in shack fires. Meters with no electricity purchases in the studied period were deleted in order to account for these. The active database consists of 163.624 users.

Only a part of Cape Town is covered by this database. The area has approximately 75% of all users receiving free basis electricity in Cape Town.

Table 8: Observation in database and total users in Cape Town

	In database	In Cape Town
Domestic 2, receiving free basic electricity	163.624 (75%)	217.104 (100%)
Domestic 2, not receiving free basis electricity		116.000
Domestic 1		190.000

It can be observed in table 8 that 15% of the users purchase more than 400 kWh/month. This may be due to the way in which free electricity is provided. Free Basic Electricity is given to all households on pre-paid meters with an average monthly consumption of 400kWh or less. When a new connection is made it is automatically given Free Basic Electricity in order to ensure that all eligible households receive the subsidy. Consumption for all consumers is checked in June each year and those whose average monthly consumption exceeds 400 kWh lose Free Basic Electricity for the coming 12 months. However the period included in the database is different from the period where consumption is controlled (June to June) so some households with an average consumption over 4,800 kWh annually are included.

Table 9: Users according to consumption

	Number of users	
1-2.400 kWh/year	21.842	13,3%
2.400-4.800 kWh/year	117.542	71,8%
4.800-7.200 kWh/year	23.297	14,2%
7.200 kWh/year or more	943	0,6%
Total	163.624	100%

If consumers do not purchase electricity in a calendar month, they lose the free electricity for that month. They need to purchase some amount each month to obtain the free electricity. On average 12% of eligible consumers do not buy electricity in any given month. The share is highest in summer, when consumption is lowest. The value of the unclaimed free electricity is approximately R5,7 million annually, or R35 per consumer. This means that on average there are 16.726 consumers that do not receive Free Basic Electricity each month even though they are eligible for it. This represents a loss of welfare for these consumers and may be due to a lack of awareness or understanding of how the current tariff system works. This probably results in the consumption of relatively dangerous energy alternatives to electricity such as paraffin. In order to address this problem Free Basic Electricity could be granted daily in the same manner as the energy service charge is calculated daily. This would remove the need for low-income households to purchase electricity monthly in order to collect Free Basic Electricity, thereby giving greater flexibility to consumers with irregular income and very low electricity consumption.

4. CONCLUSION

The current tariff system in Cape Town is generally well constructed and encompasses the target group for Free Basic Electricity. There do, however, appear to be problems in low-income groups in understanding the tariff system and the large jump in variable costs for consumers on the cusp of qualifying for Free Basic Electricity. Two alternatives to the current tariff are introduced, one with a simplified tariff system and the other with a slowly increasing variable cost. Neither addresses both issues simultaneously.

The load curves in Cape Town show that consumption is not affected by large daily or seasonal variations. This indicates that there are large, constant loads in the Cape Town distribution area and that domestic cooking is not responsible for large morning and evening peaks. Energy efficiency initiatives aimed at reducing peak demand should, therefore, be aimed at large consumers in the domestic and private sector rather than at low-income consumers. Energy efficiency in low-income households can, however, have beneficial effects on quality of life and energy poverty. Low tech solutions and behavioural programmes may be beneficial as well as information campaigns.

Purchasing patterns indicate that 12 % of eligible consumers do not receive Free Basic Electricity each month. This probably results in a loss of welfare for these households. Free Basic Electricity could be calculated on a daily basis in order to ensure that Free Basic Electricity is readily available for households with irregular incomes and very low consumption that do not necessarily purchase electricity in each calendar month.

5. BIBLIOGRAPHY

Andersen, F.M., and Togeby, M.: *Analysis of Demand Response in Denmark*, Risø National Laboratory, Roskilde, 2006.

City of Cape Town: *Study on the social profile of residents of three selected informal settlements in Cape Town. Survey results and study findings - household profile, perceptions and opinions of residents.*, 2005

Rodriques, E., Gie, J. & Haskins, C., Information and Knowledge Management Department, City of Cape Town: *Informal Dwelling Count (1993-2005) for Cape Town*, 2006

City of Cape Town: City Statistics www.capetown.gov.za/wcmstemplates/sdigis.aspx?clusid=477&catparent=6956&IDpathString=6952-6956, 2007

Cowan, B: *Household Energy Use*. Energy Research Centre, University of Cape Town, 2006

Eskom: *Energy Efficiency and Demand Side Management in South Africa*, Eskom, Johannesburg, 2007

.

Howells, M., Victor, D.G., Gaunt, T., Elias, R.J. & Alfstad, T.: "Beyond free electricity: The costs of electric cooking in poor households and a market-friendly alternative". *Energy Policy*, 34 pp. 3351–3358, 2006.

Lloyd, P, and Cowan, B: "Improving access to electricity: Lessons from Khayelitsha". *Conference on Domestic Use of Energy* 2005

NER (2006): Multi-Year Price Determination of Eskom, 1 April 2006 – 31 March 2009, Final determination with consitions, NER.

NERSA (2007): NERSA Consultation Paper on the Municipal Tariff Guideline and Review of the Benchmarks for the Financial Year 2008/2009, NERSA.

Lloyd, Philip and Eugine Visagie (2007): The testing of gel fuels, and their comparison to alternative cooking fuels. In Domestic use og energy conference 2007.

Pollack, M: Cost comparisons between LP Gas and electricity. www.capetown.gov.za/clusters/viewarticle2.asp?conid=13005, City of Cape Town, undated

University of Cape Town ~~(2002)~~: *Options for a basis electricity support tariff. Analyses, issues and recommendations*. Eskom and Department of Minerals and Energy. Research project 400903, 2002

University of Cape Town: *Options for a basis electricity support tariff. Supplementary report*. Eskom and Department of Minerals and Energy. Research project 400903, 2003.

Schemmel, J. P.: "Market-based instruments to support environmental fiscal reform in South Africa. A Discussion Document." Chapter 7 in: *Environmental Fiscal Reform for Sustainable Development and Poverty Reduction*. Workshop Proceedings and Country Case Studies, 2004

Davie, K.: "How green is my budget?", *Mail & Guardian*, 28 October 2007.

Statistics South Africa (2007): *Community Survey*, www.statssa.gov.za/community_new/content.asp, 2007

Principal Author:

Edward James-Smith holds a B.Sc. in biochemistry from Free State University, Bloemfontein and a M.Sc. in technology and socio-economic planning from Roskilde University in Denmark. At present he is working as an advisor at Ea Energy Analyses where his main focus areas are energy efficiency, regulation in the energy sector, energy economics, energy scenarios and power system planning.

Co-author:

Mikael Togeby holds a PhD in Engineering in Deterministic Chaos in Energy Systems from the Technical University of Denmark. He is currently a partner in Ea Energy Analyses and is specialised in demand response, DSM, electricity prognosis, analyses of electricity demand, statistical analyses and power system planning

Presenter:
The paper is presented by Edward James-Smith