THE PILOT TESTING AND FINDINGS OF THE RESIDENTIAL TIME-OF-USE TARIFF (HOMEFLEX) PROJECT FROM AN ESKOM PERSPECTIVE

Eskom

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ABSTRACT

This paper explains the objective of the Residential Time-of-Use tariff (Homeflex) project, the background of the project, the market drivers that support the Homeflex project, the pilot objectives and describes the details of the pilot tests that were conducted. The data evaluation, analysis and findings of the pilot tests conducted in Tableview (Cape Town) and Sandton (Johannesburg) sites are also discussed.

1. INTRODUCTION

Eskom identified the need for the introduction of a Time of Use tariff for residential customers more than 8 years ago. Since then, a tariff (Homeflex) was developed and various pilot projects were run. At the same time various other load management and efficiency strategies were also being studied and tested in the market. These load shifting technologies were not integrated with the tariff.

Due to the changes with the Wholesale Electricity Pricing System (WEPS), Eskom's Integrated Strategic Electricity Plan (ISEP), the Electricity Supply Industry (ESI) and the Electricity Distribution Industry (EDI), the above tariff became outdated.

Taking into consideration the internal and external transformation, a revised business case for the Homeflex project was approved by Eskom Distribution. The revised business case recommended a strategy of piloting a Homeflex tariff similar to the structure of the Wholesale Electricity Pricing System tariff together with an automated load management device (geyser control) that would be provided to the customer as part of the Homeflex package.

A residential time of use (TOU) tariff was tested at various sites around the country over the period 1998-2003 (inclusive).

2. THE OBJECTIVE OF HOMEFLEX PACKAGE

The objective of the Homeflex Pilot Project was to develop and introduce a residential time-of-use (TOU) tariff that will penetrate the market and provide incentives and benefits to the customers, which will ultimately result in the optimization of the country's peak demand curve profile.

3. THE MARKET SUPPORT FOR HOMEFLEX

The following are market drivers that support the implementation of the Homeflex Package:

a) The continued increase in Eskom's peak demand and requirements for increased capacity decisions that need to be made.
b) A distributor's requirement for increased sales in off peak periods.
c) The Energy Policy White Paper stipulations for cost reflective tariffs, differentiated capacity charges and sophisticated tariffs for the upper market.
d) The increased customer needs for flexibility and lower costs, which ultimately increases customer satisfaction due to reduced bills and more value adding options.
e) The strong differential in the tariff's peak to off peak ratio encourages customer to shift which can reduce the Distributor's purchase costs and increase profitability.
f) The Homeflex tariff is designed on the WEPS principles, creating a better alignment of the Homeflex tariff to the WEPS. This serve to accurately reflect the cost of energy

generation and consequently provide pricing signals that would reduce the purchase costs., thereby resulting in improved net contribution for the Distributor.

g) there is an increased incentive to shift load,.

4. THE HOMEFLEX PILOTS

4.1 THE OBJECTIVES OF PILOTING

The primary aim of the pilots was to determine whether a time-of-use (TOU) pricing signal would encourage customers to shift their electricity consumption from peak to off peak periods. Other aspects that were tested in the pilots were the customer's acceptance of and response to the tariff and load management technologies, and Eskom Distribution's support structure's ability to handle the Homeflex tariff. The support structures involved in the Homeflex pilot tests included Metering, Billing, Customer Contact Centre and Field Services.

4.2 THE PILOTS

The following sites were tested:

- Sandton (Johannesburg)
- Tableview (Cape Town)
- An unspecified area in Durban, piloted in conjunction with eThekwini Electricity. (Data analysis of the Durban site will not be reported on in this paper).

Each site consisted of a control group, a 2-part TOU (TOU2) sample, and a 3-part TOU (TOU3) sample, with approximately 50 consumers per category at each site, making an experiment total of 450 consumers.

All of the consumers on the Homeflex pilot tariffs were retrofitted with load management devices which were either timers installed to the Hot Water Storage Heaters (geyser), or centrally switched radio ripple-control devices. The Hot Water Storage Heaters (HWSH) was programmed to switch off the customer's Hot Water Storage Heater during the morning and evening peak periods.

Customers were given continuous education on how to manage the tariff as well as other energy efficiency information.

5. CONSUMERS TARGETED BY THE TARIFF

5.1 CHARACTERISATION OF CONSUMERS WITH HWSH

Data collected in the last 10 years by a National domestic load research project in South Africa[1] was queried to estimate the penetration of hot water geysers in communities with different levels of consumption.

Figure 1 illustrates the findings. Each point represents aggregate measures from groups of 60 or more households at a research site over a year.

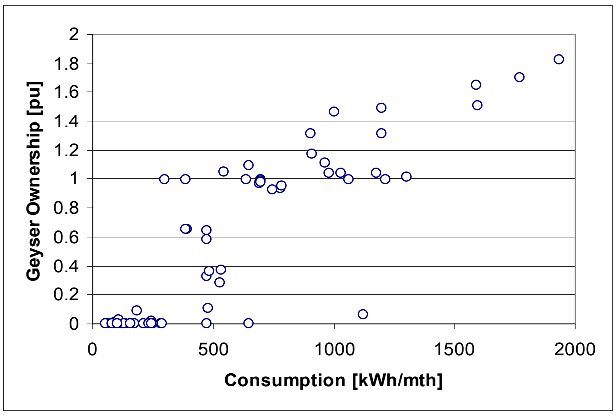

Figure 1: Relationship between HWSH penetration and Consumption in communities (Source NRS LR Project 1994-2003)

The relationship between consumption and HWSH penetration in the region of 500 kWh can be modelled as a step function.

This relationship implies that if a geyser-activated tariff is applied to consumers with less than 500 Kwh/month aggregate consumption, then diminishing returns will result.

5.2 POTENTIAL AUDIENCE OF ESKOM DOMESTIC CONSUMERS

From an Eskom point of view, small and medium domestic consumers on conventional meters (i.e. the "Homepower" tariff) are all potential targets for this type tariff.

An analysis of these Eskom consumers is presented in figure 2. About 75 % of these Homepower consumers used 1000 kWh/month or less over this period. The potential audience for such a tariff may therefore be the proportion of customers who use

[1] The NRS load research project

500kWh/month or more. This constitutes about 60 % of this customer segment (113,000 consumers)[2].

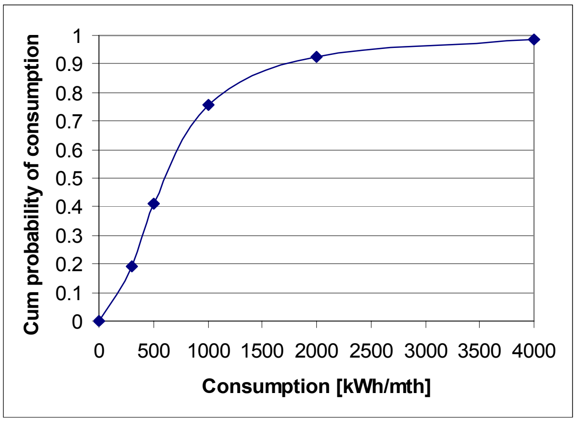

Figure 2: Cumulative probability of average monthly consumption for Eskom "Homepower" consumers, Year 2002.

6. TECHNICAL EVALUATION OF THE PILOT SITES

About 52,000 hourly load readings were collected during the course of the pilot project onto a project database at Eskom.

6.1 THE DATA RESOURCE

All pilot/control site data was filtered to exclude the following:

- Consumers with incomplete data.
- Consumers on a 'special' TOU tariff at Sandton.
- Periods of change where the state of the sample/control experiment was uncertain.

After filtering, the data set shown in Table 1 was usable.

Table 1: Summary of experimental source data available for analysis after filtering

Site	Count per category	Analysis potential
Durban	60	Summer 2000, Winter 2001[3]
Sandton	41	Winter 2002, 2003 Summer 2002
Tableview	50	Winter 2001, 2002, 2003 Summer 2001, 2002

[2] Source: Eskom Homepower (C1,C2 and C3) customer sales, over year 2002. Source data drawn from Eskom sales database (CRP), Aug 13, 2004.

[3] Potential at this site is limited by uncertainty surrounding early tariff data of 1998, 1999.

6.2 INDICATIONS OF PROFILE MODIFICATION

An investigation was carried out to identify the difference in load profile (sample versus control) between consumers with the same levels of consumption, and to test the significance of the causal variables (Tariff, TOU).

For this purpose, sample and control consumers were binned according to discrete ranges (i.e. bins) of consumption over the same time period for each site to derive an average profile for consumers with or without 2-part or 3-part TOU.

The widths of consumption-bins were chosen specifically for each site in order to maximise the certainty of results at each location.

During this process, it became apparent the sample design of the experiment was marginal and any attempt to bin consumers led to a rise in levels of uncertainty.

Aggregate profiles were generated for consumers in each bin & tariff:

- hour (Time of day)
- day-type (Weekday/weekend)
- season (High/Low), as defined by the tariff

The differences between the Control, TOU2 and TOU3 tariffs in the different periods were also used to investigate the relative effect of the tariff on the household profile at a given time of the day.

These analyses were based only on the comparison of profiles for consumers in the similar consumption classes, and ignored the effect of the tariff on energy consumption.

Figure 3 shows the measured response for mid-range consumers in Tableview, during High-season, 2002. Aggregate consumption at this site was about 900kWh/consumer/month, and peak time shedding at this site was effected by radio control.

Figures 3 and 4 show load profiles which have been normalised to the consumption of the control group at each location. The figures show the control group (CON), 2-part TOU group (TOU2) and 3-part group (TOU3).

Differences between control and TOU2/TOU3 groups are distinct. About 0.8 kW per consumer appears to have been shifted from the average Tableview peak periods (30% reduction).

The different responses to TOU2 and TOU3 at this site are not distinct.

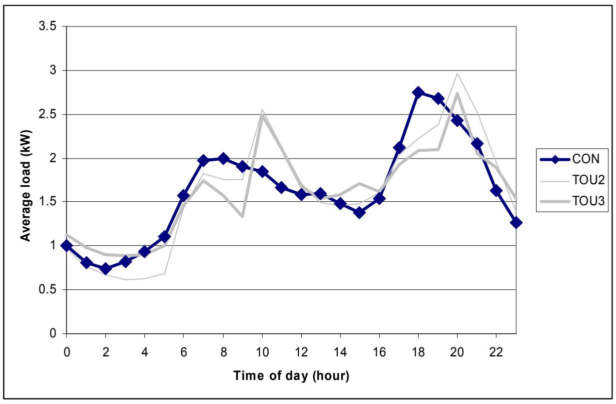

Figure 3: Average high-season weekday profiles for mid-range consumers in Tableview, 2002.

Figure 4 shows the measured response of mid-range customers at Sandton during High-season, 2002.

Aggregate consumption at this site was 2200 kWh/consumer/month. The HWSH of Sandton consumers were controlled by local timers. These timers could be over-ridden by the consumers. Therefore it is possible that shedding times were diversified by the consumers, in order to better suit the living habits of their households.

About 0.8-1 kW/consumer appears to have been shifted from the average Sandton peak periods (20% reduction).

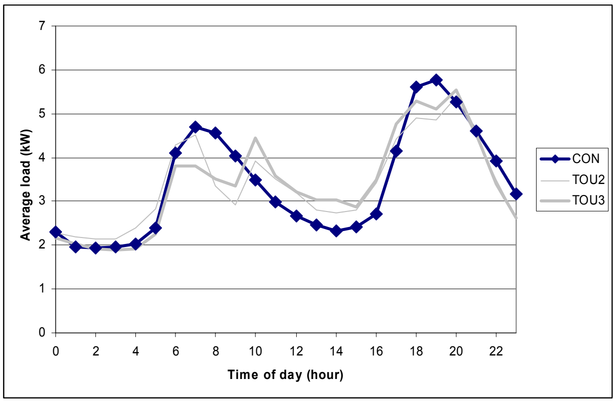

Figure 4: Average high-season weekday profiles for mid-range consumers in Sandton, 2002.

Again, the different responses of TOU2 and TOU3 at this site are not distinct.

Also apparent in this sub-set is a poor indication of recovery of the shifted energy at evening peak after the HWSH load was restored. This is an indication of noise associated with low sample numbers. Variance between the load profiles of consumers of a similar annual consumption is appreciable, and this carries important implications for sample design of such domestic consumers.

6.3 FINDINGS OF THE DATA EVALUATION

<u>Effect of TOU2 versus TOU3</u>

Our analysis of this data indicated the effect of TOU2 is indistinguishable from TOU3. Analyses of the difference between the tariffs show that the variant of TOU used is statistically insignificant.

This is consistent with research which shows high-end consumers are relatively inelastic to changes in the price of electricity as a group.

<u>The effect of TOU versus non-TOU</u>

We found the effect of TOU versus non-TOU to be statistically very significant, which suggests that most of the profile modification witnessed is simply due to the operation of the shedding devices installed on the consumers' HWSH.

<u>Effect of TOU tariffs on energy consumption</u>

Historical sales data from consumers at the sites was correlated with the load profiles on the Homeflex database, and before/after tests were run to ascertain what effect (if any) the onset of the tariff had on the consumption of electricity.

The change in consumption solely due to onset of TOU2 or TOU3 was found to be statistically insignificant.

7. NATIONAL EFFECTS MODELING

A generalised load model was assembled to estimate the effects of load shifting on the national load, and on revenue from these consumers.

Consumers were divided into two groups, for the Tableview and Sandton sites:

- Control consumers
- Consumers subject to TOU

Data was then extracted for these consumers over the entire Year 2002, as this was the time interval when load control devices (of some form) were installed and active at each site.

This data was then aggregated into a mean annual load profile for consumers with and without TOU at each site.

Using the control and the pilot consumer groups at each site, a linear interpolation model was built between these two groups of customers, at each time of day over the entire year 2002.

Therefore 8760 hourly models were assembled for each of the pilot and control groups.

The model has the following shortcomings, but was indicative of the underlying shape functions which are primarily related to consumption levels:

- East/West displacement and differing climates of these two sites
- Central controller versus timer controller
- Differences in Saturday response at the two sites

Using this model, the typical response of a group of TOU consumers at any arbitrary consumption level can be quickly estimated (given the normal concerns about extrapolation outside areas of applicability).

Figure 5 shows the estimated pilot and control profiles of the two pilot sites after modelling.

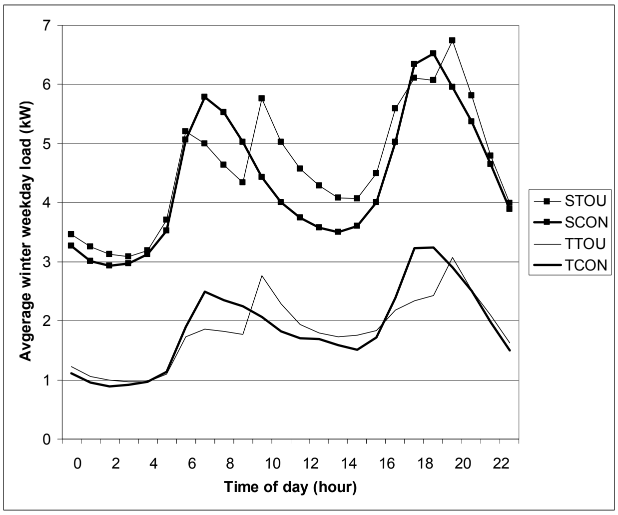

Figure 5: Modelled average high-season weekday profiles for all consumers for Sandton (S) and Tableview (T), 2002.

Figure 6 below illustrates the evaluation process in which the hourly load profile models were used.

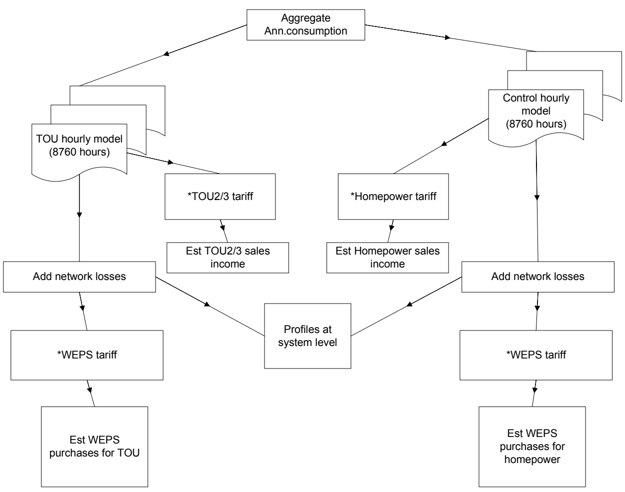

Figure 6: Schema for evaluation of the domestic TOU

The following method was used to evaluate the effect of TOU sales and consumption at National levels:

a) The annual hourly profile model for TOU and control groups was used to estimate a consumer-group profile using aggregate consumption as a variable.
b) TOU and Control sales at the LV side were estimated based on TOU and Homepower tariff models, applied to the result of (a) above.
c) Network losses were added to the results of (a) above to estimate load at the Bulk level.
d) Apply WEPS PSO pricing to the result of (c) above to arrive at "cost" for the bulk supply to these customers.
e) Present the results.

The model has been used to estimate the effect of Homeflex upon Sales, Purchases, and system demand at various times of the year.

The results from the model indicate that the impact of the tariff at a national level is marked, as is shown in Table 2.

Table 2: Estimated impact on national peak, during average High-season week day

Time-slot	Average peak *reduction* [kW/consumer]	Average Peak reduction [kW][4]
7-8	0.76	86,735
8-9	0.70	79,959
9-10	0.57	64,635
18-19	0.72	81,713
19-20	0.71	81,223

The table shows that on an average weekday, between 64 and 86 MW may be shifted out of the peak periods during the high season.

During low-season weekday, this reduction in demand reduces significantly, and may be about 60% of this figure.

8. POSSIBLE IMPLEMENTATION STRATEGIES

From the pilot tests conducted, it was noted that the current Eskom Distribution business can support the implementation of the Homeflex tariff.

[4] Eskom Homepower customers only (domestic) 2003.

There is however some concern regarding the metering technologies, the capital costs of the meter and the metering and billing integration mediums.

With the vast amount of technologies, products and packages available in the market place, investigations into the metering, load management and billing aspects required for implementation have already begun.

Numerous cutting edge metering, billing, load management and data management products have been identified at competitive prices.

A request for an automated metering, load management and data management proposal has already been sent out to the market. This Request for Proposal is currently being evaluated by Eskom, Distribution.

The selected technologies will be tested for implementation readiness, system integration, solution performance and customer acceptance in a Proof of Concept phase which is planned for the last quarter of 2006 and early 2007.

9. CONCLUSIONS

1) Homeflex may be usefully practiced on consumers using more than 500 kWh/month. The potential market for this tariff in Eskom is thus about 113,800 consumers, with aggregate consumption of about 1232 kWh/month.
2) The response to a 2-part or 3-part residential Homeflex tariff is not distinguishable, but was distinguishable from the control groups.
3) The introduction of a residential Homeflex tariff did not appear to change levels of consumption.
4) An hourly load model was established in MS Excel and used to estimate the response to Homeflex for a defined group of Homepower customers. The estimated national network effect of Homeflex was to move 65-87MW out of the morning peak period and about 81-82 MW out of the evening peak period.
5) It may well be that it is the tariff that is the **glue** that keeps the load shedding devices in place, operating normally and untampered.
6) In order to make a load management strategy most successful, the customer must see direct benefits. A Time-of-Use tariff is an extremely effective strategy which provides immediate incentives to the customer to do load shifting, thereby reaping direct benefits.

10. ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of the following:

- Jeremy Cheek: Innosol CC
- Dr S Heunis, Heunis Solutions CC
- Andrew Berrisford, Berrisford Power Management Services CC
- Hendrik Barnard, ELEXPERT (PTY) LTD
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