

Who benefits? The impacts of time-of-use electricity pricing on demographic groups in Ontario, Canada

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Abstract

In an effort to address its current electricity supply crisis by encouraging conservation, the Canadian province of Ontario has committed to installing interval metering infrastructure and implementing time-of-use pricing for all of its 4.2 million residential households by 2010. This 'smart metering' strategy is a departure from current electricity pricing policy, in which residents essentially pay a flat rate. While much of the debate surrounding the move relates to the energy and economic benefits that could accrue to the province as a whole through load-shifting, little attention has been paid to how individual households might stand to 'win' or 'lose' from this pricing shift. To begin to explore this critical issue, this paper analyses consumption, demographic, and behavioural data from 225 households located in a south-western Ontario community. The households' electricity bills were calculated in two ways: by means of the conventional flat rate (which was still in effect during the six-month period under investigation) and by means of 'time-of-use' pricing (given that 'smart meters' were installed on all of these households). While the average electricity cost for these 225 households remained virtually unchanged, there were significant differences at the margins: under time-of-use pricing, one household would have experienced a cost increase of 14 %, while another, a cost decrease of 18 %. While the correlations were found to be weak, they indicated that higher occupancy (specifically with more children) lower income households experienced, proportionately, higher costs. The social and policy implications of these disaggregated results are investigated.

Introduction

The Canadian province of Ontario, where the average house uses approximately 1,000 kWh of electricity per month, is changing the way in which its residential customers are charged for electricity. Rather than paying the same price for a unit of electricity, no matter when that unit is consumed, residential customers that have some kind of 'smart meter' will soon have the price determined by when they consume that unit of electricity. With the province committed to thousands of new smart meters in Ontario households by 2007 – and complete coverage by 2010 – this change will soon affect all residential customers in Ontario.

The purpose of this paper is to investigate the extent to which residential customers will – in the absence of changes in consumption patterns – be affected, in terms of the amount of money they pay for electricity, by this change to the new 'time-of-use' pricing regime. In many instances, it is advertised that, 'on average', customers will not see much change in their electricity bill. (Note here that there is a separate discussion regarding the extent to which this movement, from the conventional 'flat rate' pricing regime to the time-of-use pricing regime, will cause a shift in customers' consumption patterns, and thus end up in lower costs for these customers. We are not, however, primarily focusing upon this issue in this paper.) For example, Princeton Light and Power, in British Columbia, Canada, notes that: 'Using the past 12 months as a model, PLP customers enjoyed a 1 % decrease in the average cost of purchased power without changing anything else.' (Princeton Light and Power Company, 2005) Indeed, the intention in moving to the time-of-use rates in Ontario was not to shift the 'burden/'

Table 1. Conventional and Time-of-Use Pricing

Conventional Electricity Prices Summer 2006		Time-of-use Electricity Prices Summer 2006		
Less than 600 kWh per month	5.8 cents per kWh (3.8 Euro cents per kWh)	On-peak	weekdays: 11am – 5pm	10.5 cents per kWh (6.9 Euro cents per kWh)
600 kWh and above per month	6.7 cents per kWh (4.4 Euro cents per kWh)	Mid-peak	weekdays: 7am – 11am; 5pm – 10pm	7.5 cents per kWh (4.9 Euro cents per kWh)
		Offpeak	weekdays: 10pm – 7am weekends: all day holidays: all day	3.5 cents per kWh (2.3 Euro cents per kWh)

'responsibility' of paying for the electricity system from one set of customers to another, but instead to be 'revenue-neutral'.

Preliminary work, however, has suggested that even when 'on average' the change in price for a set of customers (in this case, residential customers) is the same (moving from one pricing regime to another), there can still nevertheless be significant differences in individual cases (Rowlands, 2006). In other words, at the 'extremes', individual customers may be 'winners' or 'losers' as a result of this change. More specifically, in this preliminary work, it was those who consume, on average, less electricity that will experience a larger increase (in relative terms) in the amount they pay.

Of course, this issue-area has received attention to date. Some utilities already advertise the fact that certain customers appear to be better candidates for time-of-use rates than others. (This is presumably at least partially because they have more/bigger candidate loads to be moved from peak to off-peak times. However, it may also be because – at least partially – that in the absence of any load-shifting or load-reduction action on their part, their total costs could fall.) Pacific Power, for example, argues that its "Time of Use program is a good option for a family that is away from home during swing shift hours (3 pm to 11 pm)" (Pacific Power, 2004). Similarly, Madison Gas and Electric encourages households with no one home during weekdays, specific appliances, and high electricity consumption levels to consider switching to time-of-use rates (Madison Gas, 2005).

But in spite of the importance of ensuring that changes in Ontario's electricity system are just and fair, there appears to be relatively few publicly-available investigations into this issue in this jurisdiction, with some notable exceptions (e.g. Ontario Social Housing Corporation, 2006).

This paper focuses on the study area of Milton, a town of approximately 54,000 in south-western Ontario, which is approximately 55 kilometres from the provincial capital of Toronto. The city's growth rate is extremely high, and the local electric utility, Milton Hydro Distribution Incorporated, has installed interval meters in all new residential developments, making it one of the first jurisdictions in Ontario to have a significant installation of interval meters. The resulting data availability allows for preliminary investigation into the potential impacts of time-of-use pricing on residential households.

Methodology

In May 2006, there were approximately 2,000 residential customers in Milton with interval meters, the majority of whom were being charged time-of-use rates. As part of an electricity-use feedback study, an initial survey of approximately 1,200 of these customers was conducted. Information was obtained

from 298 households regarding housing and appliance types, current consumption behaviour and conservation attitudes, as well as demographic indicators. As information was being solicited specifically from households with interval meters, the majority of which were brand new, the sample base was fairly homogenous, and not necessarily representative of a 'typical' southern Ontario city.

For 225 of the 298 customers, interval meter data was obtained dating back to the time when the meters were first installed – as far back as October 2004 for some customers, although the majority of customers had interval meter data beginning in May 2005. Milton Hydro did not begin charging time-of-use rates until early October 2005, and as such, the period of study for this paper is from early May to early October 2005.

Using hourly consumption data for this period, the monthly commodity rates (i.e. the cost of the electricity alone) were calculated using both conventional pricing and time-of-use pricing for the 225 customers. Table 1 illustrates the conventional and time-of-use electricity rates. These prices were in effect at the time of analysis, in August 2006, and they have since been changed as of November 1, 2006.

The cost change of the time-of-use charge relative to the conventional charge was then calculated for each month, and an average percentage change for the 6-month period from May to October 2005 was then calculated for each customer. A negative value indicates the customer is saving money with time-of-use pricing, and a positive value indicates they are paying more. In addition, the overall average cost change for all 225 customers was calculated.

Using the average 6-month percentage change value for each household as the response, variables from the survey data were then tested to investigate possible trends amongst the 'winners' and 'losers' by performing correlation calculations. Table 2 delineates the variables that were tested.

Results

INDIVIDUAL AND OVERALL COST CHANGES

A hypothesis test was performed on the overall average electricity cost change for all 225 households, using the null hypothesis that this value was equal to zero. This test was found to be insignificant, and the null hypothesis was not rejected, meaning the overall cost change is essentially equal to zero.

Table 3 summarizes various statistical descriptives of the cost change variable.

Table 2. Survey-Derived Variables Investigated for Correlation

Variables Tested	Description	Value Range
Total household size	# of residents per household	1 – 5
Number of children per household	# of children under the age of 21	0 – 3
House size	Data obtained in house area ranges, so midpoint values of 3 ranges were used for analysis	1,500 – 3,500 square feet (139 – 325 square metres)
Household Income	Data obtained in income ranges, so midpoint values of 4 ranges were used for analysis	CDN\$ 50,000 – 110,000 (Euro 32,900 – 72,360)
Regular summertime thermostat set temperature	Temperature residents set their thermostat to when at home during the summer	14 – 29 degrees Celsius
Survey respondent age	Taken as a proxy for household-head age as household-heads were asked to complete the survey	25 – 59

Table 3. Average Monthly Cost Change Variable Characteristics

Descriptive	Statistic
Mean	-0.4 %
Minimum	-18 %
Maximum	14 %
10th Percentile	-7 %
50th Percentile/Median	-0.4 %
90th Percentile	6 %

CORRELATION OF DEMOGRAPHIC VARIABLES AND AVERAGE COST CHANGE

Table 4 outlines the significant correlations from the tested variables. It should be noted that, while there were variables that were found to significantly correlate with the electricity cost change, all bivariate correlations were relatively small. In fact, there is a general rule of thumb that even statistically significant correlation coefficients should be greater than or equal to 0.21 for the correlation to be considered valid.

There was one bivariate correlation with the cost change dependent variable that was found to be significant and valid: number of children per household. Two other independent variables, total household size and household income, were found to yield statistically significant bivariate correlations with cost change, but these were slightly less than 0.21.

The number of children per household was found to positively correlate with the average household cost change, which may suggest that families with more children will tend to ‘lose’ with time-of-use pricing compared those with less children. Household size itself also resulted in a positive correlation, although this was just on the cusp of the 0.21 rule of thumb cut-off.

Household income was also just less of 0.21, but was found to correlate negatively with the average household cost change. While the correlation is very weak, this could suggest that, as

incomes increase, households tend to ‘win’ with the new time-of-use pricing scheme.

Discussion

The overall average electricity cost change of zero for the 225 households under investigation is in line with the results of the initial work by Rowlands (2006). Indeed, it is not surprising that the result is similar as Rowlands used a larger sample size (minimum N = 1,226), and the 225 for this study would have been included in that larger group.

As it was the intention of time-of-use pricing policy to remain ‘revenue-neutral’ on average, the cost change result of zero in this analysis could imply that this intention has been met. From this perspective alone, an argument can be made to leave the tariff structure ‘as is’, as opposed to, for example, moving to a simpler 2-band time-of-use tariff structure.

With regard to customer impact, although the overall average change is zero, there are of course individual cases where there were ‘winners’ and ‘losers’. As illustrated in Table 3, the maximum individual cost change was +14 %, meaning that household would have paid an additional 14 % with the time-of-use pricing scheme averaged over the 6-month period. The minimum individual cost change was -18 %, meaning that, on average, that household would have saved 18 %. With regard to percentile groupings, 10 % of the customers would have seen an average monthly decrease in the electricity commodity portion of their monthly bill of at least 7 %, and 10 % would have seen an increase of at least 6 %.

Looking for potential trends amongst these ‘winners’ and ‘losers’, Table 4 lists the significant correlations that were found. It must be kept in mind that, although significant, these correlations are still rather small, and two of them are just slightly lower than that 0.21 rule of thumb cut-off. Therefore, these results are presented only as initial findings that require further

Table 4. Correlations with Test Variable and Average Cost Change

Test Variable	Correlation with Average Cost Change	Significance (2-tailed)
Number of Children per Household	0.208* (Pearson Correlation)	0.003
Household Income	-0.204* (Spearman Correlation)	0.005
Total Household Size	0.161** (Pearson Correlation)	0.034

* Correlation is significant at the 0.01 level (2-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

investigation with a larger, more representative sample size, particular with regard to Ontario-wide income ranges, as this sample represents a relatively high income category.

That said, the initial findings may imply that higher income, smaller households tend to 'win' with time-of-use pricing, while lower income, larger households tend to 'lose', and there are obvious equity implications associated with this. In addition, although this result does not capture consumption behaviour changes that time-of-use pricing could promote, there are other reasons why lower income groups may be less able to take advantage of the new pricing scheme. Low income, high occupancy households may have fewer discretionary loads (i.e. loads beyond those necessary to sustain basic household functions at specific times of the day), and may therefore be less likely to 'shift' usage to off-peak times to take advantage of the cost savings that time-of-use pricing could offer. Research has shown that households with more appliances have a greater ability to shift their consumption to off-peak times (Baladi, Herriges, & Sweeny, 1998), and lower income groups may generally own fewer appliances and therefore be less likely to shift. However, other research indicates that lower income homes who are able to shift may benefit from TOU pricing (Moholkar, Klinkhachorn, & Feliachi, 2004).

If further research supports a positive correlation between consumption and income, in terms of overall electricity shifting and conservation at a macro level, it may be the case that higher income households represent the most overall potential for savings (there was a significant positive correlation found between income and consumption in this work, although it was very weak at less than 0.21). However, the question remains as to whether the cost savings to be had by taking advantage of the time-of-use price signal is enough motivation for higher income households. In addition, if higher income households receive a slight price signal (i.e. a decrease in their bill) when they are switched to time-of-use pricing without any consumption changes on their part, it is possible that they may be less likely to further alter their consumption patterns to take advantage of the new pricing scheme.

Future Work and Conclusions

As this work investigates only the hypothetical impact of a pricing scheme change in the absence of consumption behaviour change, the next step is to assess the changes that have occurred since the introduction of time-of-use prices, and this data is now available for the same May to October period in 2006. Indeed, a larger analysis of an entire annual billing cycle should be investigated using current electricity prices in order to ensure the 'revenue-neutral' nature of the pricing scheme is maintained, as well as assess the magnitude of the 'winners' and 'losers'.

This initial work suggests linkages between household size and income levels that may have equity implications as time-of-use pricing is deployed in Ontario. This should be considered alongside the broader equity issue that time-of-use pricing will enable peak users to pay commensurate rates for their electricity which will not need to be subsidized by off-peak users. While preliminary and limited, this paper's findings may be helpful in informing more detailed analyses to better understand ap-

propriate pricing scheme implementation strategies that will benefit all Ontarians.

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References

- Baladi, S. M., Herriges, J. A., & Sweeny, T. J. (1998). Residential response to voluntary time-of-use electricity rates. [Electronic version]. *Resource and Energy Economics*, 20, 225-244.
- Madison Gas and Electric. (2005). *Time of use rates*. Retrieved May 2006, from <http://www.mge.com.proxy.lib.uwaterloo.ca/images/PDF/Brochures/Residential/TimeofUse.pdf>
- Moholkar, A., Klinkhachorn, P., & Feliachi, A. (2004). Effects of dynamic pricing on residential electricity bill. *Power Systems Conference and Exposition, IEEE PES*, 2, 1030-1035.
- Ontario Social Housing Corporation. (2006). *Electricity metering and social housing in Ontario*. Toronto, ON: Ontario Social Housing Corporation.
- Pacific Power. (2004). *Who will benefit from pacific power's time of use program?* Retrieved May 2006, from <http://www.pacific-power.com.proxy.lib.uwaterloo.ca/Article/Article17183.html#Q9>
- Princeton Light and Power Company. (2005). *Time of use programs and rates*. Retrieved May 2006, from http://www.plpower.com.proxy.lib.uwaterloo.ca/TOU_Rates.htm
- Rowlands, I. H. (2006). *Alternative pricing regimes in Ontario: Exploring the impacts*. Presentation at the CEATI workshop on 'Understanding customer response', Toronto, 11 May 2006