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March 27, 2008

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
P.O. Box 2319
27th Floor
2300 Yonge Street
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: Board File Number EB-2006-0303
Evaluation of Time-of-Use Pricing Pilot

As required by the Ontario Energy Board's December 13th 2006 Decision approving Veridian Connections Inc.'s proposal for the implementation of a Time-of-Use Pricing Pilot Project, we are pleased to submit the enclosed project evaluation report as prepared by Navigant Consulting Inc.

Navigant's report was prepared in consultation with Board staff to ensure consistency with the analytical approach used to evaluate other similar pilot projects conducted in the province.

Please do not hesitate to contact me if you have any questions regarding this material.

Yours truly,

original signed by

George Armstrong
Manager of Regulatory Affairs and Key Projects

cc Michael Angemeer
Dave Clark
Axel Starck
Rob Scarffe
Todd Williams, Navigant Consulting Inc.

NAVIGANT CONSULTING

EVALUATION OF TIME-OF-USE PRICING PILOT

Presented to

55 Taunton Road East,
Ajax, ON
L1T 3V3

MARCH 18, 2008

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EXECUTIVE SUMMARY

This report summarizes the design, operation and outcomes of the Veridian Connections (Veridian) Time-of-Use (TOU) pricing pilot study undertaken from February 2007 through the end of September 2007. The pilot project tested the response of mid-size to large general service customers (>200 kW peak demand) to Regulated Price Plan (RPP) Time-of-Use rates.

All eligible Veridian RPP business consumers with peak demand greater than 200 kW were offered an opportunity to participate in the pilot through an offer letter with an opt-out provision. Of the 46 eligible customers, eight customers chose not to participate, leaving 38 participants. Given the types of customers who were eligible to participate and the subset of eligible customers who chose to participate (i.e., those who did not opt-out), the final group of 38 participating customers was comprised almost entirely of multi-residential and MUSH (municipalities, universities, schools and hospitals) customers. All of the multi-residential customers were "bulk-metered" – individual units in these facilities were neither individually metered nor individually billed.

Prior to their participation in the pilot, participating customers were subject to a two-tiered pricing structure, one price for monthly consumption under a tier threshold and a higher price for consumption over the tier threshold. For the designated multi-residential customers, the threshold is 600 kWh per month (summer) or 1000 kWh per month (winter) per residential unit, while the threshold for the MUSH customers is 750 kWh per month. When the participants started the pilot, they had been paying tier prices of 5.5 cents per kWh for consumption below this threshold and 6.4 cents per kWh for consumption above this threshold.

Under the RPP TOU pricing structure, prices are based on three time-of-use periods. These periods are referred to as Off-Peak, Mid-Peak and On-Peak. The lowest (Off-Peak) price is below the tier prices, while the other two are above them. The three prices are related to each other in approximately a 1:2:3 ratio.

Findings

Based on Navigant Consulting's analysis of the consumption patterns of the participants in Veridian's TOU pricing pilot, the following conclusions can be drawn:

- The two customer segments participating in the pilot – multi-residential, bulk-metered customers and MUSH customers – exhibited different responses to and experienced different impacts from TOU prices.
- Based on weather-corrected (i.e., normal weather) consumption in the pre-TOU and TOU periods, multi-residential participants decreased their consumption by 2.8% on

average under TOU prices, and MUSH participants also decreased their consumption but by only 0.1%.

- The TOU prices implemented by the Board are consistent with the Government's policy goal of all consumers paying the true cost of the electricity they consume. The impact of the change to TOU prices is very dependent on what customers would otherwise pay under the tiered RPP pricing structure:
  - Over 80% of the multi-residential pilot participants' consumption in the TOU period would have been at the lower Tier 1 price. These participants experienced a slight increase of just over 1% in their average unit commodity charge (i.e., cents per kWh) under TOU prices. Note that the price these participants would otherwise pay under tiered pricing is somewhat less than the actual cost to supply them, whereas the price they paid under TOU prices was more reflective of the actual cost to supply them. Combined with their 2.8% decrease in consumption noted above, the overall commodity costs for multi-residential participants in the pilot declined slightly (i.e., 2.8% reduction in overall usage combined with a 1% increase in unit commodity charge).
  - On the other hand, almost all of the MUSH pilot participants' consumption would have been at the higher Tier 2 price in the TOU period. These participants experienced a reduction of approximately 10% in their average unit commodity charge. As with the multi-residential participants, the price that MUSH participants paid under TOU prices was more reflective of the actual cost to supply them.
- Multi-residential participants exhibited different *price elasticities* in each of the three TOU periods: -4% for consumption in the On-Peak period; -14% in the Mid-Peak period; and +7% in the Off-Peak period. Similarly, the price elasticity for MUSH participants was found to be -1% for consumption in the On-Peak period, +10% in the Mid-Peak period; and -4% in the Off-Peak period.
- The estimated *elasticity of substitution* for multi-residential customers ranged from +0.7% to +0.9% depending on whether the elasticity of substitution was based on On-Peak versus "Non On-Peak" (ie, Mid-Peak and Off-Peak combined) consumption or "Non Off-Peak" (ie, On-Peak and Mid-Peak combined) to Off-Peak consumption. The corresponding elasticity of substitution for MUSH participants was found to range from -1.8% to -0.8%.

It is important to note that all of the multi-residential participants in the pilot were bulk-metered. The electricity consumers in the individual units within these multi-residential facilities would have had little or no incentive to change their overall consumption and consumption patterns under TOU prices. For example, if a unit resident incurred costs to shift or reduce their usage, that resident would incur all the costs but the benefits of their

actions (i.e., lower commodity charges) would be shared with all of the other residents in the apartment or condominium. This is similar to the concept commonly referred to as the "*Tragedy of the Commons*." In contrast, if the unit resident was individually-metered and billed, that resident would realize all of the benefits of their actions in the form of lower commodity charges. The Government's current initiative to install smart sub-metering systems in condominiums as set out in Regulation 442/07[1] would provide such an incentive to unit residents in condominiums.

Given that all of the multi-residential participants in the pilot were bulk-metered, the results of this pilot should not be taken as representative of what individually metered multi-residential consumers would do under TOU prices. A pilot specifically involving individually metered multi-residential consumers would be necessary to provide such information.

Note, also, that the pilot involved a relatively small number of participants and the pilot duration was only eight months. Hence, the results provided herein represent short-term impacts for a small group of customers. It would be expected that the elasticity and responsiveness of customers would increase over time as their behaviour changes and they install equipment and institute operational changes that help them to take advantage of TOU prices.

[1] See the Ministry of Energy website: www.energy.gov.on.ca/index.cfm?fuseaction=electricity.smartmeters

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INTRODUCTION

This report summarizes the design, operation and outcomes of the Veridian Connections (Veridian) Time-of-Use (TOU) pricing pilot study undertaken from February 2007 through the end of September 2007. The pilot project tested the response of mid-size to large general service customers (>200 kW peak demand) to Regulated Price Plan (RPP) Time-of-Use rates.

Results from the pilot study are drawn through quantitative analysis of the demand response via load shifting away from On-Peak hours to either Mid-Peak or Off-Peak hours and electricity conservation.

Information gathered from this pilot study will enable Veridian and other LDCs to expedite and enhance general service customer response to RPP TOU rates when they are implemented more broadly. The results from the study will also support and inform the communications efforts of Veridian and other LDCs with MUSH (municipalities, universities, schools and hospitals) and other customers when their eligibility for RPP prices ends (currently expected to be May 1, 2009). Finally, load shape information from participating customers will help the Ontario Energy Board to more accurately forecast the "residual" RPP load shape when MUSH customers leave the RPP.

Pilot Objectives

The specific objectives of the pilot test are as follows:

1. Test the response of medium-sized designated general service customers (with peak demand >200 kW) to RPP TOU prices
2. Compare the response of certain of the above customers against their previous consumption patterns on the tiered RPP rates (Veridian had hourly consumption data for at least 12 months prior to the beginning of the pilot period for more than half of the participating customers)
3. Explore customer reaction to LDC efforts to reduce their consumption (conservation) and increase their price responsiveness (demand management) through education and seminars.
4. Estimate the customer elasticity of substitution of medium-sized general service customers (with peak demand > 200 kW) and compare that to residential consumers in the other RPP TOU pilots underway in Ontario.

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Ontario Energy Board Approval

On July 28, 2006, the Ontario Energy Board (the "Board") amended the Standard Supply Service Code (the "SSS Code") to allow certain electricity distributors to charge time of use prices for consumers on the Regulated Price Plan (the "RPP") with eligible time-of-use meters as part of a pilot project. The amended SSS Code requires approval from the Board in order for any new pilot projects to be implemented.

On November 21, 2006, Veridian Connections submitted a proposal for approval to implement a pilot project involving TOU electricity prices and eligible TOU (or "smart") meters in relation to medium-sized general service consumers with peak demand of more than 200 kW.[2] After reviewing the proposal, the Board approved Veridian's pilot project for many reasons, notably that the results obtained for general service customers through the Veridian pilot will complement the residential TOU pricing pilot projects underway in Ontario[3].

Standard and TOU Rate Structure

Under amendments to the *Ontario Energy Board Act, 1998* (the Act) contained in the *Electricity Restructuring Act, 2004*, the Ontario Energy Board was mandated to develop a Regulated Price Plan (RPP) for electricity prices to be charged to consumers that have been designated by regulation. The first prices were implemented under the RPP effective on April 1, 2005, as set out in regulation by the Ontario Government.

The principles that have guided the Ontario Energy Board in developing the RPP were established by the Ontario Government. In accordance with legislation, the prices paid for electricity by RPP consumers are based on forecasts of the cost of supplying them and must be set to recover those forecast costs. RPP prices are currently reviewed and adjusted if necessary by the OEB every six months.

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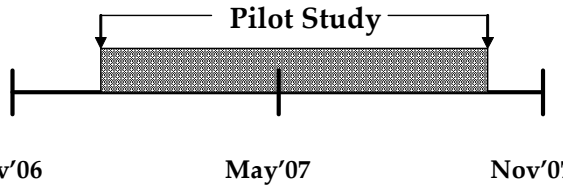
[2] Veridian's proposal was assigned Board File No. EB-2006-0303 by the OEB.

[3] Ontario Energy Board, IN THE MATTER OF the Ontario Energy Board Act, 1998, S.O. 1998, c. 15, Schedule B; AND IN THE MATTER OF a proposal by Veridian Connections Inc. to implement a Time-of-Use Pricing Pilot Project under section 3.9.1 of the Standard Supply Service Code., Pamela Nowina, Presiding Member and Vice Chair, and Paul Vlahos, Member, December 13, 2006. EB-2006-0303. The Board decision is posted on the OEB website at: www.oeb.gov.on.ca/documents/cases/EB-2004-0205/smartpricepilot/verdian_tou_decision_141206.pdf

During the Veridian pilot study, customers were exposed to two separate sets of TOU prices since the OEB reset the prices on May 1st, 2007. Figure 1 outlines the different RPP periods experienced during the pilot study.

Figure 1: Two RPP Periods Experienced During the Pilot Study



Standard Meter Regulated Price Plan

The conventional meter RPP has a two-tiered pricing structure, one price for monthly consumption under a tier threshold and a higher price for consumption over the tier threshold. Until October 31, 2005, the threshold was 750 kWh per month for all consumers. From November 1, 2005, the tier threshold for residential consumers has changed twice a year on a seasonal basis: to 600 kWh per month during the summer season (May 1 to October 31) and to 1000 kWh per month during the winter season (November 1 to April 30). The threshold for non-residential RPP consumers continues to remain constant at 750 kWh per month for the entire year.

Subsequent to April 2006, the RPP prices were reviewed by the Board every six months and adjusted, if necessary. The RPP prices in effect during this study reflect this resetting frequency and are shown in Table 1.

Table 1: Conventional RPP Prices

Cents per kWh	Apr'05-Apr'06	May'06-Oct'06	Nov'06-Apr'07	May'07-Oct-07
Tier 1	5.0	5.8	5.5	5.3
Tier 2	5.8	6.7	6.4	6.2

TOU Regulated Price Plan Prices

Subsequent to a date to be determined by the Ontario Energy Board, eligible RPP consumers with eligible time-of-use (or "smart") meters that can measure and record electricity consumption for hourly (or shorter) intervals will pay under a time-of-use (TOU) RPP price structure. The prices under this plan are based on three time-of-use periods. These periods are referred to as Off-Peak, Mid-Peak and On-Peak. The lowest (Off-Peak) price is below

the tier prices, while the other two are above them. The three prices are related to each other in approximately a 1:2:3 ratio.

The RPP TOU prices are also reviewed and adjusted every six months. The following table outlines the TOU prices in effect during the pilot. Note that TOU prices in effect prior to February 2007 (when TOU prices came into effect for study participants) are not relevant to this study. Our analysis of the pilot participants' response to TOU prices reflects the RPP prices in effect during the period being analyzed.

Table 2: Distribution of RPP TOU Prices During the Pilot Study

Cents per kWh	Nov'06-Apr'07	May'07-Oct-07
Off-Peak	3.4	3.2
Mid-Peak	7.1	7.2
On-Peak	9.7	9.2

The hours and prices for each of these three time-of-use (TOU) periods are set out in Table 3.

Table 3: Breakdown of RPP TOU Hours for Summer and Winter Periods

Time	Summer Hours (May 1 – Oct 31)	Winter Hours (Nov 1 – April 30)
Off-Peak	10pm – 7am weekdays; all day on weekends and holidays	10pm – 7am weekdays; all day on weekends and holidays
Mid-Peak	7am – 11am and 5pm and 10pm weekdays	11am – 5pm and 8pm – 10pm weekdays
On-Peak	11am – 5pm weekdays	7am-11am and 5pm-8pm weekdays

Figure 2 graphically displays the winter TOU prices based on the Board's May 1, 2007 RPP price setting, while Figure 3 shows summer TOU prices based on the same price setting.

Figure 2: Winter TOU Prices (May 1 2007 RPP Price Setting)[4]

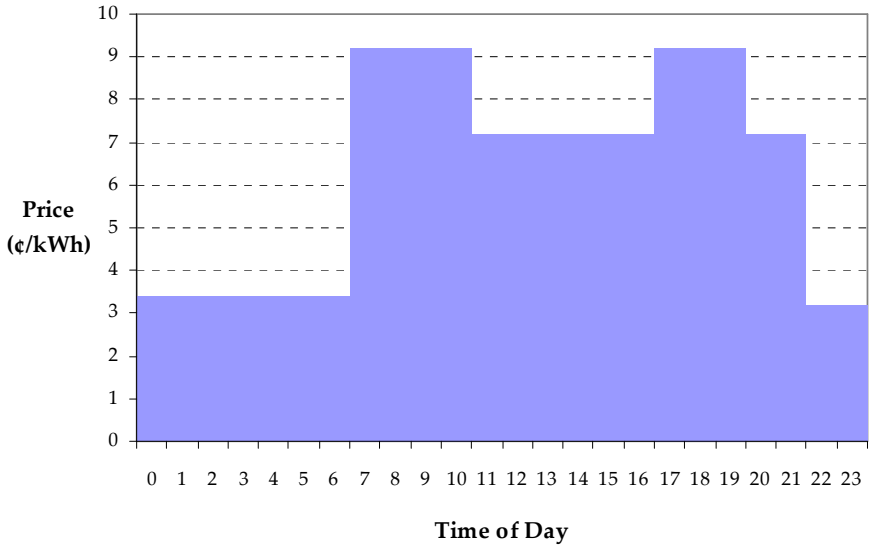
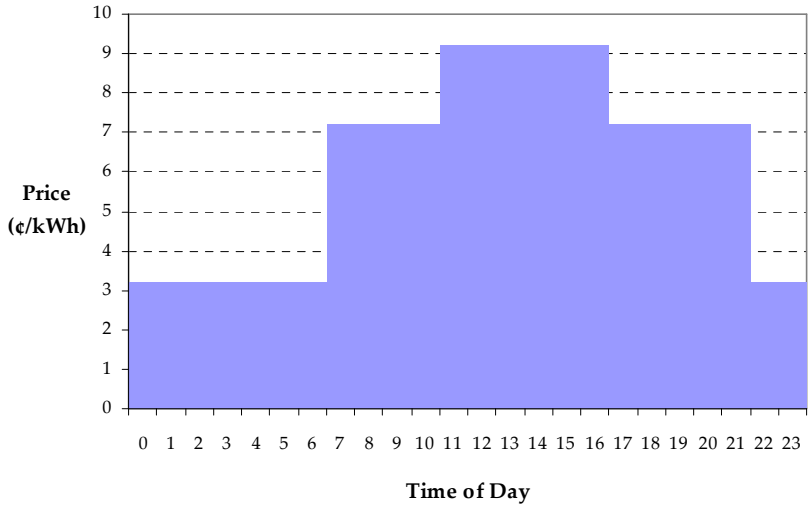


Figure 3: Summer TOU Prices (May 1 2007 RPP Price Setting)



The average price a consumer on TOU prices will pay will depend on the consumer's load profile (i.e., how much electricity is used at what time). RPP prices are set so that a

[4] The May 1 2007 RPP price resetting covered the subsequent 12 month period through April 30, 2008 and included both summer and winter TOU pricing. The winter TOU prices were reset on November 1, 2007 and became effective on the same date. The November 1, 2007 price setting also included summer TOU pricing, which may get reset by the Ontario Energy Board on May 1, 2008.

consumer with the average RPP consumption level and load profile will pay the same average price under either the tiered or TOU prices, as shown in Table 4. Specifically, Table 4 shows the RPP prices that were in effect during the latter half of the pilot. This average price is equal to the average RPP supply cost of approximately 5.7¢/kWh.

Table 4: Average RPP Prices (May `07 – Oct `07)

Tiered RPP Prices	Tier 1	Tier 2	Average Price
Price	5.3¢	6.2¢	5.7¢
% of RPP Consumption	53%	47%	

TOU RPP Prices	Off Peak	Mid Peak	On Peak	Average Price
Price	3.2¢	7.2¢	9.2¢	5.7¢
% of RPP Consumption	48%	29%	23%	

PILOT PARTICIPANTS

All eligible RPP consumers with peak demand greater than 200 kW were offered an opportunity to participate in the pilot. Customers were recruited with an opt-out provision (i.e., the recruitment letter included wording along the lines of: "*You have been randomly selected to be on TOU rates as part of a test being undertaken by Veridian Connections. If you do not want to participate in this test, please let us know and we will exclude you from the test.*").

This recruitment approach was chosen over a strictly voluntary (or opt-in) recruitment approach (e.g., "*please let us know if you want to participate*") to address a number of critical issues: (1) there is a significant risk of self-selection bias under a strictly voluntary recruitment approach; (2) "mandatory recruitment" to spot market pricing is essentially what will happen to some of these customers when they are no longer eligible for the RPP; and (3) it reduces the recruiting period significantly, ensuring that the pilot is operational as soon as possible.

Of the 46 eligible customers with peak demand greater than 200 kW, eight customers chose not to participate, leaving 38 participants. Given the types of customers who were eligible to participate and the subset of these eligible customers who chose to participate (ie, those who did not opt-out), the final group of 38 participating customers was comprised almost entirely of multi-residential and MUSH (municipalities, universities, schools and hospitals) customers, with one additional participant being a place of worship. For simplicity, this participant was considered as a MUSH customer in our analysis. Note that all of the multi-residential customers were "bulk-metered" and that the individual units in these facilities were neither individually metered nor individually billed.

Test Structure and Design

Given the small number of participants, Veridian chose not to break the participants into different cells or to offer specific treatments to subgroups. However, in our analysis, we have split the participants into the two segments – multi-residential and MUSH – in an effort to identify differences in the response of these segments to TOU prices. As noted, the MUSH segment included one place of worship.

Hourly smart meter interval data for all of the participating customers was made available to Navigant Consulting through Veridian's secure meter data website. Each pilot participant's load data was downloaded from the website beginning with the earliest available data. Hourly meter data as far back as 2004 was available for the majority of the customers, and hourly meter data starting in 2006 through 2007 was available for the remainder.

Time-of-use meter data was available for all 38 customers after the TOU prices came into effect, however hourly consumption data for at least twelve months prior to the commencement of the pilot project was only available for 21 customers. Our analysis focussed on those 21 participants for whom at least 12 months of pre-TOU hourly meter data was available to improve the statistical reliability of our findings. A breakdown of these participants by customer "type" is provided in Table 5.

Table 5: Breakdown of Participants by Customer Type

MUSH	Multi-Residential
8	13

Note that although the sample of participating customers is relatively small, the analogous customer group (i.e., RPP consumers with peak demand > 200 kW) in other LDCs is similarly small.

Veridian also undertook a survey of participants but the response rate was very low (less than 5% or participants completed the entire survey). Given this low response rate, the survey results were not analyzed.

Pre-TOU Consumption Patterns

The following figures provide the typical winter and summer weekday load profiles for the multi-residential and MUSH participants in the pre-TOU period. Extreme winter and summer days are also provided for comparison in the figures.

The figures clearly demonstrate that MUSH participants' consumption was much less sensitive to extreme weather (both winter and summer) than that of the multi-residential participants.

As shown in Figure 4, the total demand for a *typical* winter day for multi-residential participants included in the analysis peaks just above 1.5 MW between 6:00 and 7:00 pm and just below 2.0 MW during that same time during an *extreme* winter day[5].

Similarly in Figure 5, the total demand for a *typical* winter day for the MUSH participants included in the analysis peaks at approximately 3.7 MW at 5:00 pm and just above 4.0 MW at 7:00 pm for an *extreme* winter day.

[5] Extreme winter day taken Feb 27, 2006 with a daytime low of -12°C.

Figure 4: Pre-Pilot Winter Weekday Load Shape for Multi-Residential Participants

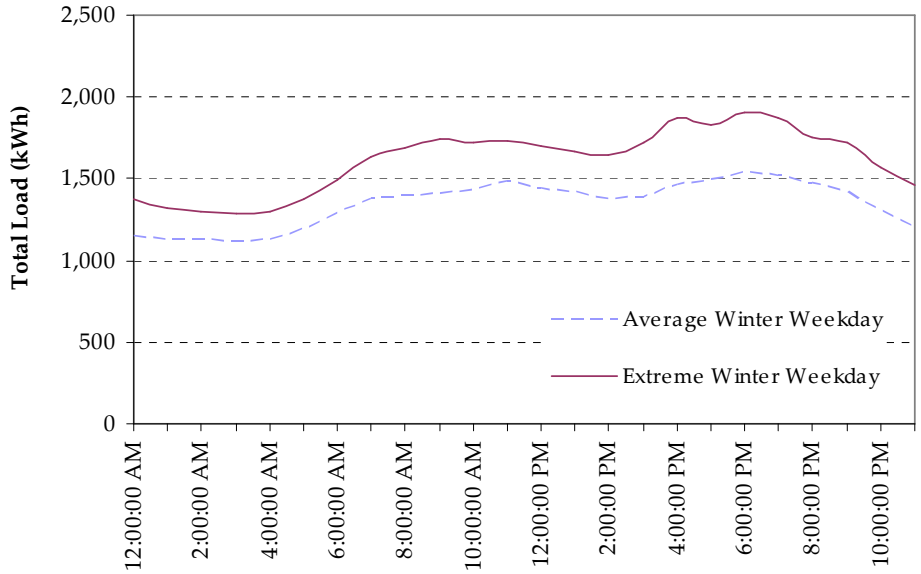
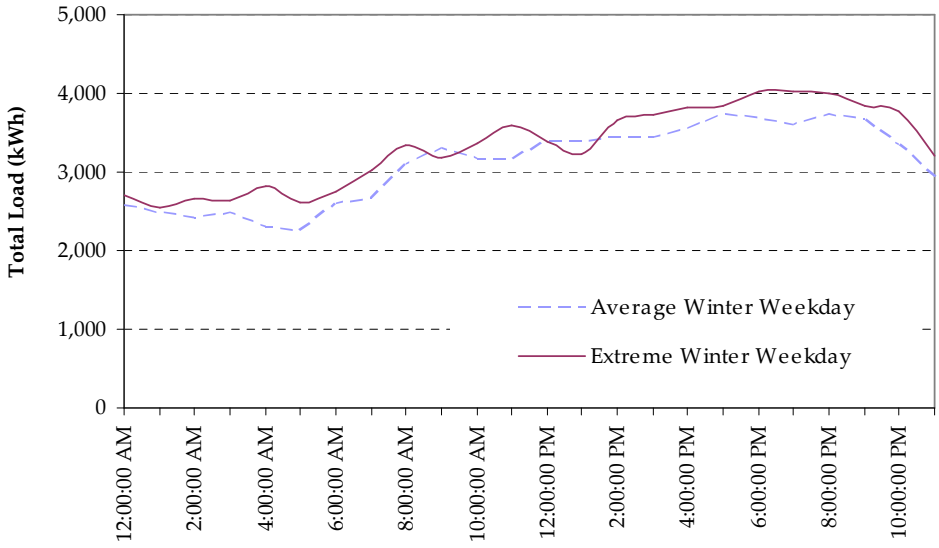


Figure 5: Pre-Pilot Winter Weekday Load Shape for MUSH Participants



As illustrated in Figure 6, the peak demand for a *typical* summer day for the multi-residential participants included in the analysis is approximately 2.1 MW between 5:00 and 6:00 pm. The demand profile for an *extreme* summer day[6] follows a similar pattern, however the peak demand increases by just under 20% to 2.4 MW during the same period.

[6] Extreme summer day taken on July 17, 2006, with a daytime high of 31°C.

Figure 7 shows the demand profile for all MUSH participants, which for a *typical* summer day, peaks just below 3.8 MW over a relatively broad period in the afternoon hours. On an *extreme* summer day, the peak demand for MUSH participants increases by approximately 5% to 4.0 MW in the afternoon hours.

Figure 6: Pre-Pilot Summer Weekday Load Shape for Multi-Residential Participants

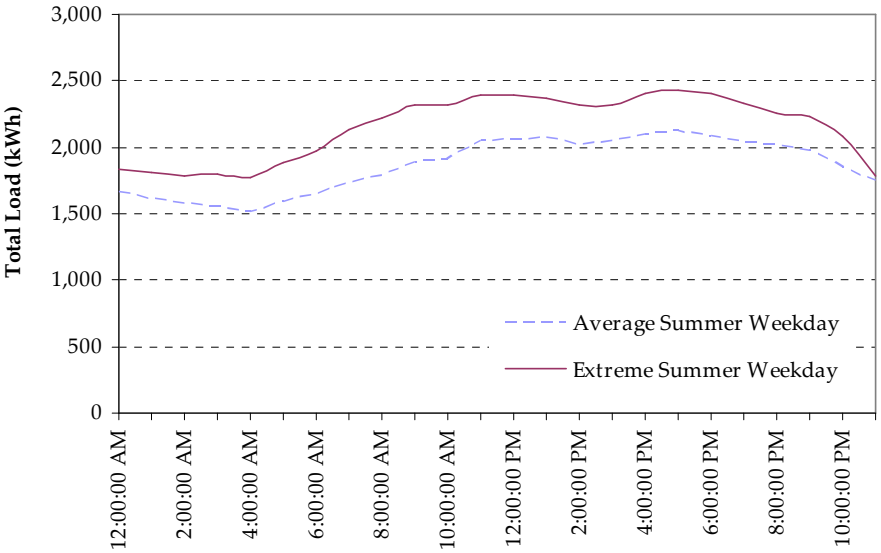
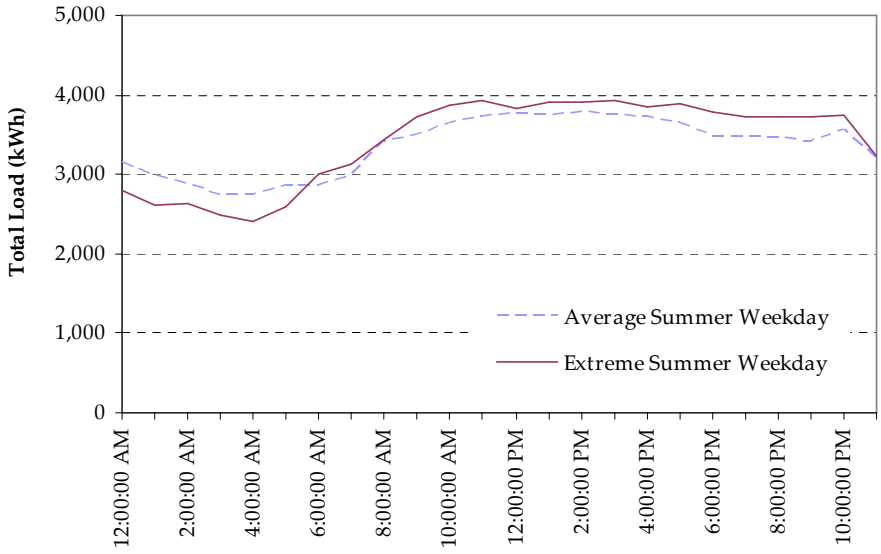


Figure 7: Pre-pilot Summer Weekday Load Shape for MUSH Participants



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CUSTOMER DEMAND RESPONSE

One of the main questions that this study was intended to address was how and to what extent customers will change their consumption patterns in response to time-of-use rates. It is expected that customers will shift consumption away from On-Peak periods (which have become more expensive) and toward Off-Peak periods (which have become less expensive). Total consumption could increase or decrease. This chapter estimates the magnitudes of these responses.

It should be noted that this study only captures short-term responses to time-of-use rates. This will include primarily changes in behaviour that are easy to make – for example, turning lights off during On-Peak periods. It is expected that additional changes will occur over time as customers further adjust their actions and acquire equipment that helps them control their electricity use – for example, installing timers on lights. Thus, the magnitude of the changes in consumption patterns observed in this study are expected to increase over time.

Analytic Approach

The approach taken in this study was to compare electricity consumption patterns before and after customers were subject to time-of-use rates. One of the challenges faced in this study was to make sure that the pre-TOU and TOU periods were as comparable as possible. The data for our analysis was raw meter data. Since this data had not been subject to Veridian's Verification, Editing and Estimation (VEE) process, some of the raw meter data contained missing observations, where consumption was recorded as zero. In order to create two datasets – pre-TOU and TOU – that are as directly comparable as possible, the following procedure was used:

- Two eight month periods were selected: February 1, 2006 – September 30, 2006 for the pre-TOU period and February 1, 2007 – September 30, 2007 for the TOU period.
- Within theses periods, only customers having functional data in both the pre-TOU and TOU period were used in the analysis. This resulted in 17 customers (44%) being removed from the analysis.[7] The majority of customers who were eliminated from the analysis did not have sufficient pre-TOU data for a complete analysis. Furthermore, one participant was removed from the analysis on the basis that new occupants moved into the facility during the pilot study.

[7] Non-functional data was taken as any data with a prolonged period of zero values, likely due to malfunction or error in the smart meter or blackouts.

Within these two periods, total consumption was calculated for four periods: On-Peak, Mid-Peak, Off-Peak weekdays, and Off-Peak weekends/holidays. This calculation was done for each individual participant and for all participants in each of the two segments analyzed.

Due to the difference in weather experienced by participants in the pre-TOU period compared with the TOU period, Navigant Consulting developed separate regression models for multi-residential and MUSH participant to estimate the aggregate consumption for all of the analyzed participants in each of these segments in each of the four time-of-use periods (On-Peak, Mid-Peak, Off-Peak weekdays and Off-Peak weekends) based on heating and cooling degree days. Using the regression model, the actual meter data was adjusted to reflect "average" weather as experienced in the period from 2001 through 2007 for both the pre-TOU and TOU periods. Within these two periods, the resultant weather-corrected consumption was calculated for each of the four time-of-use periods based on the segment-specific regression model results.

Findings

Consumption Pattern

The following figures show average hourly consumption in the pre-TOU and TOU period for multi-residential and MUSH participants for an average summer weekday and weekend and an average winter weekday and weekend. In Figure 8 and Figure 9, the summer morning consumption (Off-Peak and Mid-Peak on weekdays, Off-Peak on weekends) for multi-residential participants appears marginally higher in the TOU period, but relatively similar for the afternoon and evening period (except evening weekends in the TOU period, where consumption tends to be slightly lower than in the pre-TOU period). On the other hand, MUSH participants seem to have increased their consumption in the early afternoon to evening consumption (On-Peak and Mid-Peak on weekdays) in the TOU period, as seen in Figure 10. Early morning consumption for MUSH participants on weekends also seems to have increased in the TOU period, as seen in Figure 11.

Figure 8: Multi-Residential Summer Weekday Hourly Demand (kWh)

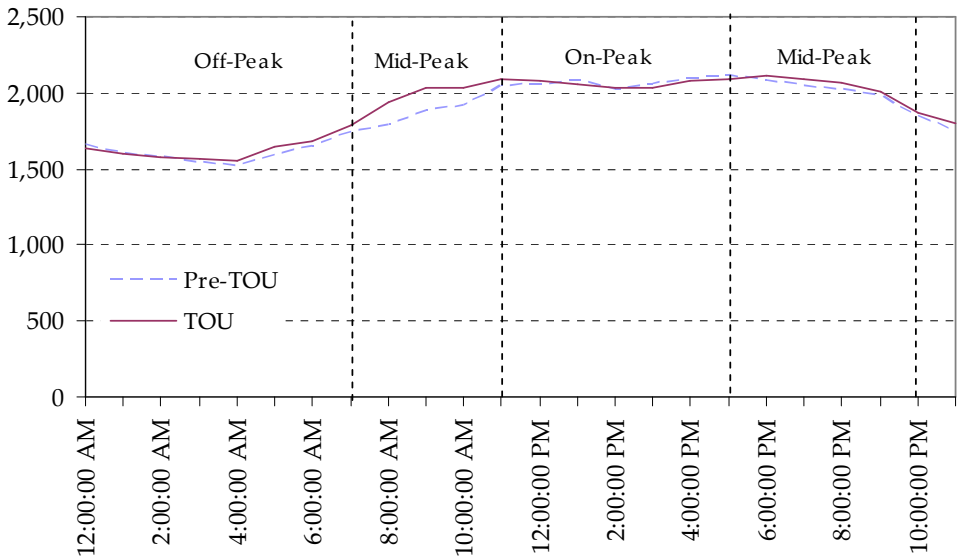


Figure 9: Multi-Residential Summer Weekend Hourly Demand (kWh)

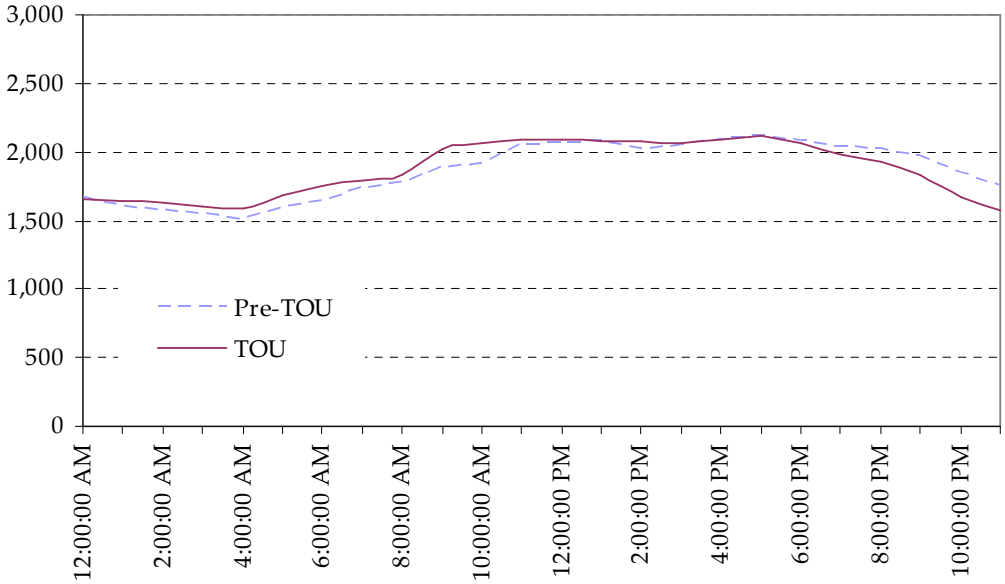


Figure 10: MUSH Summer Weekday Hourly Demand (kWh)

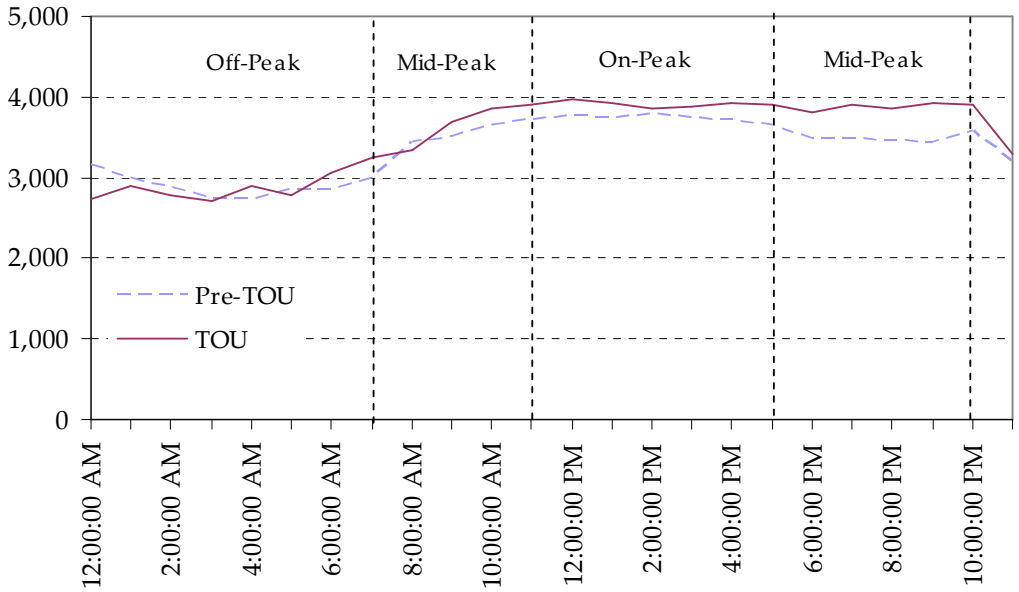
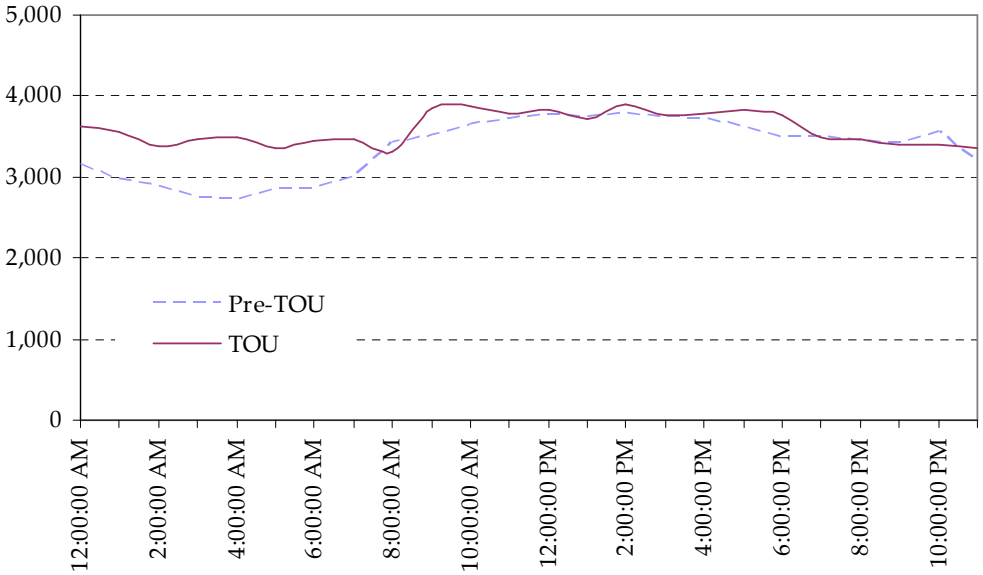


Figure 11: MUSH Summer Weekend Hourly Demand (kWh)



In terms of the winter consumption, Figure 12 and Figure 13 show that mid-morning consumption for the multi-residential participants is marginally higher in the TOU period, and drops slightly below pre-TOU levels for the On-Peak hours during weekday evenings. For MUSH participants, late morning and early afternoon winter consumption (On-Peak and Mid-Peak on weekdays, Off-Peak on weekends), is marginally higher in the TOU period, as shown in Figure 14 and Figure 15. However, there does seem to be a small

reduction in consumption during the evening hours (Mid-Peak during the week, Off-Peak on weekends) in comparison to the pre-TOU period. Other differences are too small to be evident in these figures.

Figure 12: Multi-Residential Winter Weekday Hourly Demand (kWh)

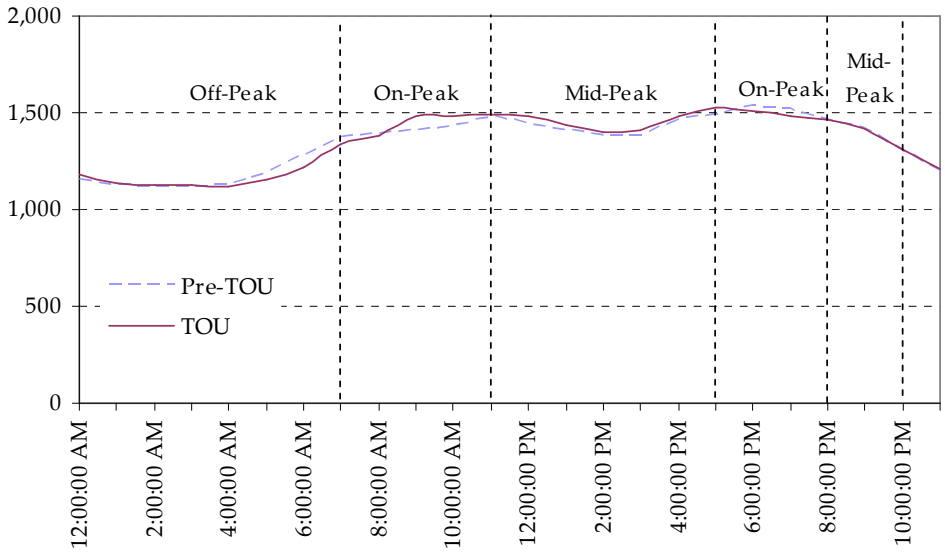


Figure 13: Multi-Residential Winter Weekend Hourly Demand (kWh)

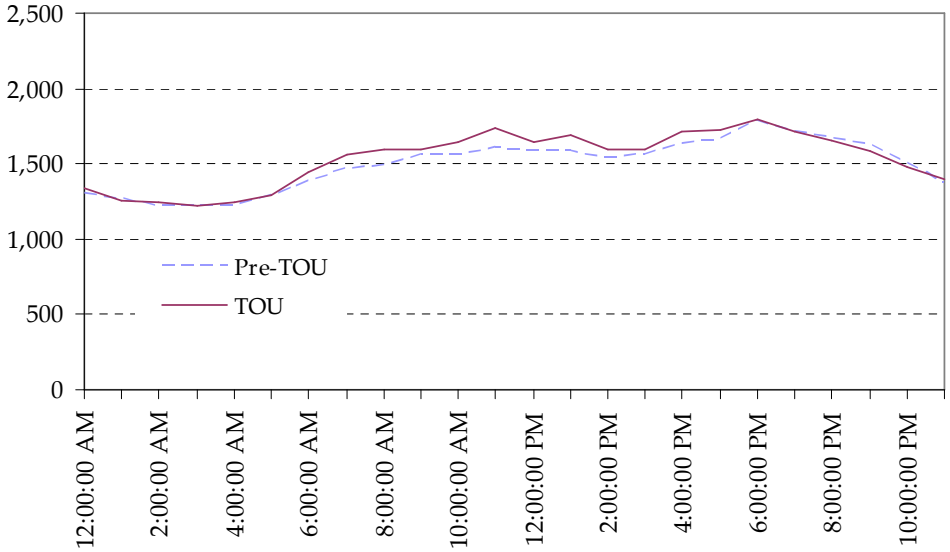


Figure 14: MUSH Winter Weekday Hourly Demand (kWh)

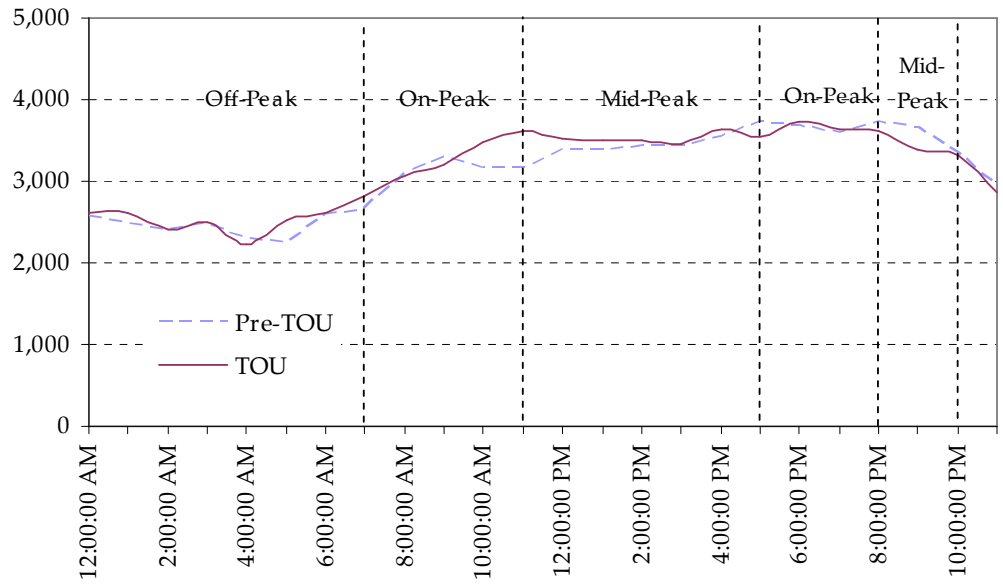
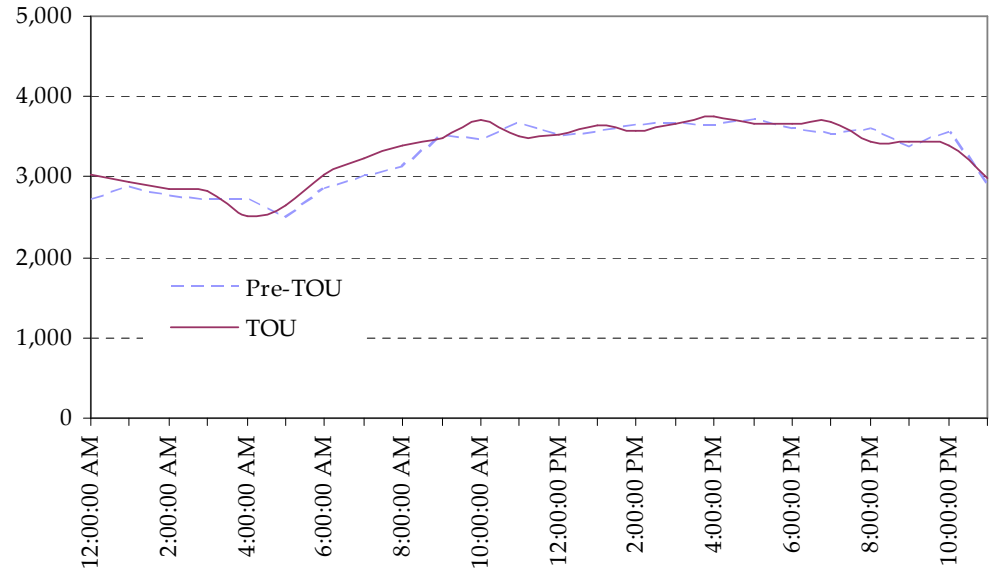


Figure 15: MUSH Winter Weekend Hourly Demand (kWh)



Conservation Effect

Other studies of time-of-use rates have found an overall conservation effect: not only do consumers shift their consumption from high-price to low-price periods, but they also reduce their overall consumption, perhaps because of an increased awareness of their electricity use. Figure 16 compares the weather corrected (ie, normal weather) consumption

for all of the multi-residential participants included in the analysis in the pre-TOU and TOU periods. Figure 17 presents similar information for the MUSH participants.[8] Based on these results, total consumption for the multi-residential participants was found to decrease by 2.8% in the TOU period compared with the pre-TOU period, and total consumption was found to decrease marginally (0.1%) for the MUSH participants. Thus, TOU rates appear to have had an impact on the overall consumption of the multi-residential participants in this pilot, but do not appear to have any significant impact on the overall consumption of the MUSH participants.

Figure 16: Total Consumption for all Multi-Residential Participants (MWh/period)

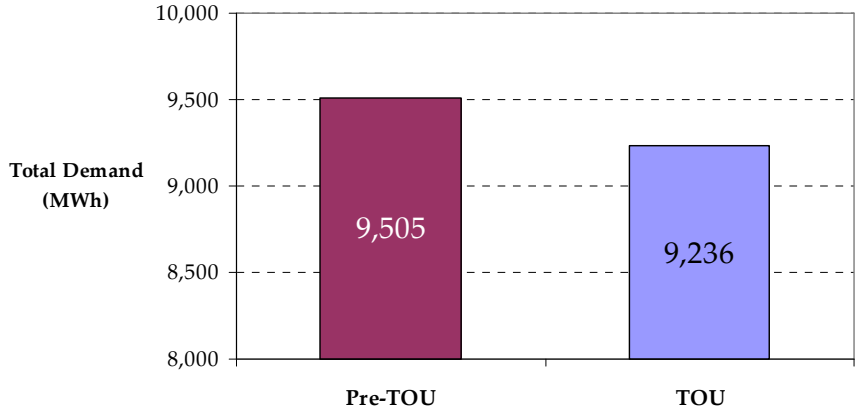
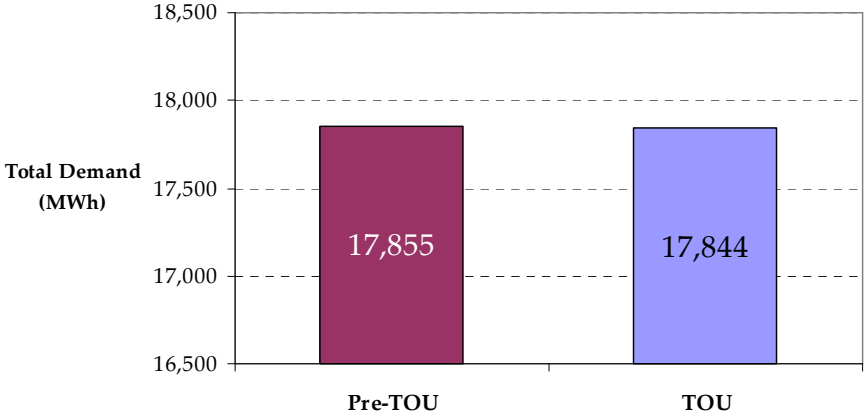


Figure 17: Total Consumption for all MUSH Participants (MWh/period)



[8] Due to the significant differences in the response of the multi-residential and the MUSH participants to TOU prices, the performance of the two segments will be reported separately in subsequent sections of this report.

Load Shifting

Figure 18 and Figure 19 show the percent of total consumption for each of the four TOU periods (with the Off-Peak period divided into weekday Off-Peak and weekends) for the analyzed multi-residential and MUSH participants respectively. Multi-residential participants exhibit a slight increase in the proportion of total consumption during On-Peak hours (0.2%) and Mid-Peak hours (0.1%), whereas MUSH participants exhibit a slight decrease (0.2%) in the proportion of total consumption during On-peak hours.

Figure 18: Pre-TOU and TOU Consumption by TOU period for Multi-Residential Participants

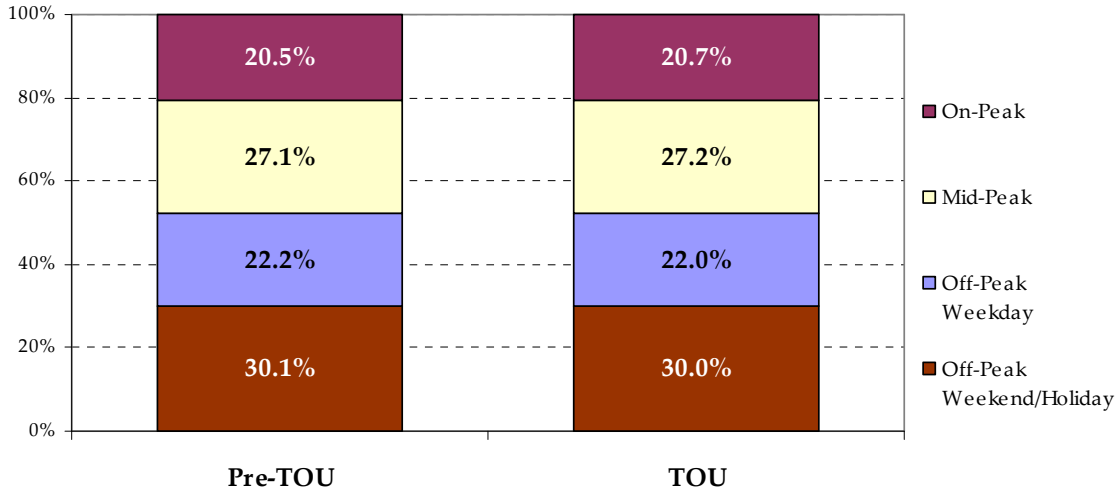
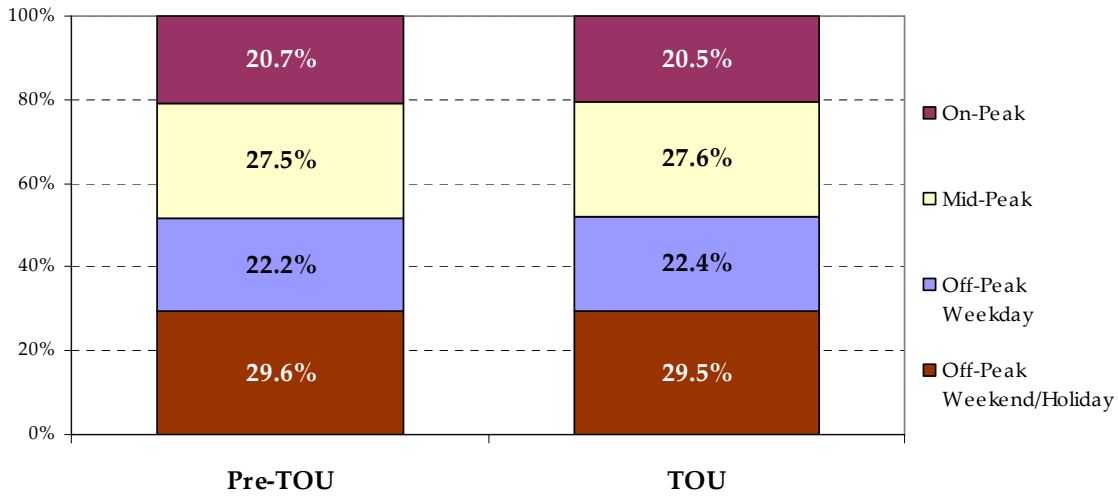


Figure 19: Pre-TOU and TOU Consumption by TOU period for MUSH Participants



Put a different way, while multi-residential participants' On-Peak and Mid-Peak consumption decreased by 2.1% and 2.3% respectively from the pre-TOU period, when expressed as a percentage of total consumption their On-Peak and Mid-Peak consumption increased by 0.7% and 0.5%, respectively. In contrast, Off-Peak weekday consumption and weekend/holiday consumption decreased by 0.9% and 0.3%, respectively, as shown in the bottom portion of Table 6. Note that the upper portion of Table 6 shows the absolute change in consumption from the pre-TOU period for each of the different TOU periods (i.e., not expressed as a percentage of total consumption).

Table 6: Change in Consumption by Segment and TOU Period

Participants	On-Peak	Mid-Peak	Off Peak Weekday	Off Peak Weekend	Off-Peak Combined
Actual Consumption (relative to consumption in corresponding pre-TOU period)[9]					
Multi-Residential	-2.1%	-2.3%	-2.3%	-2.3%	-3.3%
MUSH	-0.3%	1.2%	2.9%	0.9%	1.7%
Change in percentage of total consumption[10], expressed as a percentage					
Multi-Residential	0.7%	0.5%	-0.9%	-0.3%	-0.5%
MUSH	-1.2%	0.5%	0.6%	-0.13%	0.19%

As shown in the lower portion of Table 6, MUSH participants' On-Peak consumption expressed as a percentage of total consumption decreased by 1.2% when expressed as a percentage of total consumption, with the Mid-Peak, Off-Peak weekday and Off-Peak weekend consumption increasing by 0.5%, 0.6% and 0.1% respectively.

[9]Calculated as [average consumption (kWh) in TOU period – average consumption (kWh) in pre-TOU period] divided by average consumption (kWh) in pre-TOU period and expressed as a percentage. For example, if the average On-Peak consumption in the TOU period was 90 kWh and the average On-Peak consumption in the pre-TOU period was 100, the result would be -10% (ie, [90 – 100]/100 = -10%).

[10] Calculated as [percentage of total consumption in TOU period – percentage of total consumption in pre-TOU period] divided by percentage of total consumption in pre-TOU period and expressed as a percentage. For example, if On-Peak consumption represented 19% of overall consumption in the TOU period and 20% of the total consumption in the pre-TOU period, the result would be 5% (ie, [19% – 20%]/20% = 5%). In the example given, On-Peak consumption expressed as a percentage of total consumption decreased by 5% – 20% x 0.95 = 19%. Note that results presented are a percentage of a percentage (5% of 20%), not the absolute change in percentage.

Table 7: Change in Consumption by TOU Period

	Full Period			Weekdays Only		
Participants	**On-Peak Pre-TOU**	**On-Peak TOU**	**On-Peak Change**	**On-Peak Pre-TOU**	**On-Peak TOU**	**On-Peak Change**
Multi-Residential	20.5%	20.7%	+0.7%	29.4%	29.6%	+0.6%
MUSH	20.7%	20.5%	-1.2%	29.4%	29.0%	-1.2%

Elasticity

The relationship between price and consumption can be quantified in two ways: as price elasticities or as elasticities of substitution.

Price elasticity refers to how much consumption of one product changes as its price changes, without regard for the price of other products. For example, as the price of electricity increases, consumers are likely to run their air conditioners less. *Elasticity of substitution* refers to how demand for two products changes as their relative prices change. For example, if electricity late at night is much less expensive than electricity during the early evening, then consumers may choose to run high consumption appliances late at night. In this case, electricity used at different times of the day are considered to be separate products.

Which of these two measures is appropriate depends on whether the product has a good and easily available substitute. For some uses, electricity use can be shifted from one time to another. For other uses, substitution is less effective; for example, running an air conditioner at night when the outside temperature is cool is not a good substitute for running it in the afternoon when temperatures are high.

In this section, both price elasticities and elasticities of substitution are calculated. No assumption is made about which one is more appropriate.

For both types of elasticities, the relevant price is the *marginal price* of electricity – i.e., the price of increasing consumption by one more unit. For customers under tier pricing, the marginal price depends on whether monthly consumption is above or below the threshold level. The threshold level for each of the multi-residential participants is determined by taking the threshold for the residential consumers (600 kWh or 1000 kWh per month, depending on the season) multiplied by number of units in the residential complex[11], while

[11] For example, a 250 unit multi-residential building would have a threshold of 162,500 kWh per month (250 x 600 kWh) during the summer season.

the threshold level for the MUSH participants (non-residential RPP consumers) remains constant at 750 kWh per month.

In the pre-TOU period, all of the MUSH participants' monthly consumption exceeded the 750 kWh/month threshold for tier 2 prices under the RPP for non-residential customers, meaning their marginal cost of electricity is the Tier 2 price. Over the 8-month pre-TOU period, this works out to 6.38¢/kWh for the MUSH participants. For the multi-residential participants, on average only 21% of their monthly consumption exceeded the residential consumer threshold (600 kWh or 1000 kWh), giving them a marginal cost of electricity of 6.14¢/kWh over the 8-month pre-TOU period.

During the TOU period, the marginal prices are simply the TOU prices, as the price (within a TOU period) does not change as the level of consumption changes. For some purposes, it will be necessary to use the average price of electricity during the combined Mid-Peak and Off-Peak periods, or during the combined On-Peak and Mid-Peak periods. This is calculated as the weighted average of consumption during the TOU period. The relevant prices are shown in Table 8 for multi-residential participants and Table 9 for MUSH participants.

Table 8: Electricity Prices for Elasticity Calculations for Multi-Residential Participants

(¢/kWh)	Feb - Apr '06	May – Sep '06	Average
Tier Prices			
Tier 1 Price	5.00	5.80	
Tier 2 Price	5.80	6.70	
Threshold (kWh/month)	1000	600	
Average Marginal Price	5.26	6.59	**6.14**
	Feb - Apr '07	**May – Sep '07**	**Average**
TOU Prices			
On-Peak Price	9.70	9.20	9.37
Mid-Peak Price	7.10	7.20	7.17
Off-Peak Price	3.40	3.20	3.27
Non-Off-Peak Price	8.22	8.06	8.12
Non-On-Peak Price	4.67	4.57	4.61

Table 9: Electricity Prices for Elasticity Calculations for MUSH-Residential Participants

(¢/kWh)	Feb - Apr '06	May – Sep '06	Average
Tier Prices			
Tier 1 Price	5.00	5.80	
Tier 2 Price	5.80	6.70	
Threshold (kWh/month)	750	750	
Average Marginal Price	5.80	6.70	**6.38**
	Feb - Apr '07	**May – Sep '07**	**Average**
TOU Prices			
On-Peak Price	9.70	9.20	9.38
Mid-Peak Price	7.10	7.20	7.16
Off-Peak Price	3.40	3.20	3.27
Non-Off-Peak Price	8.20	8.05	8.10
Non-On-Peak Price	4.71	4.62	4.65

Price elasticity is defined as the percentage change in the quantity demanded compared to the percentage change in the price. On-peak, Mid-Peak and Off-Peak electricity can be treated as three separate products. In the pre-TOU period, the price was the same for all three. The resulting price elasticities for multi-residential customers, shown in Table 10, range from -13.9% to 7.0% (the minus sign indicates that as price increases, demand decreases, which is true for most products), while the price elasticities for MUSH customers, shown in Table 11 range between -0.6% and 9.7%.

Table 10: Price Elasticities for Multi-Residential Customers

Time Period	Change in Demand	Change in Price	Elasticity
On-Peak	-2.1%	52.7%	-4.0%
Mid-Peak	-2.3%	16.8%	-13.9%
Off-Peak	-3.3%	-46.8%	7.0%

Table 11: Price Elasticities for MUSH Customers

Time Period	Change in Demand	Change in Price	Elasticity
On-Peak	-0.3%	47.1%	-0.6%
Mid-Peak	1.2%	12.4%	9.7%
Off-Peak	1.7%	-48.7%	-3.6%

The *elasticity of substitution* of two products is the ratio of (1) the *percent change* in their relative demand (the ratio of demand for the first product divided by the demand for the second product) to (2) the *percent change* in their relative prices. In the pre-TOU period, prices for all three "types" of electricity (On-Peak, Mid-Peak and Off-Peak) were the same, so the price ratio was 1. This changed under TOU prices.

As shown in Table 12 for multi-residential customers, the elasticities of substitution between on-, mid- and Off-Peak electricity are all positive and range from 0.7% to 0.9%. For MUSH participants, the elasticities of substitution are all negative and range from -4.8% to -0.4%, as shown in Table 13. The calculation is complicated by dealing with three products instead of two; for example, the change in the demand for Mid-Peak electricity could be a result of its lower price compared to On-Peak electricity, its higher price compared to Off-Peak electricity, or both. A simpler approach is to collapse the three products into two: i.e., compare On-Peak electricity to Mid- and Off-Peak electricity combined, or compare Off-Peak electricity to on- and Mid-Peak electricity combined. This is shown in the last two columns of Table 12 and Table 13. The result is a range of estimated elasticity of substitution of 0.7% to 0.9% for multi-residential customers and -1.8% to -0.8% for MUSH customers depending on whether the elasticity of substitution is based on On-Peak to Non On-Peak consumption or Non Off-Peak to Off-Peak consumption.

Table 12: Elasticities of substitution for Multi-Residential participants

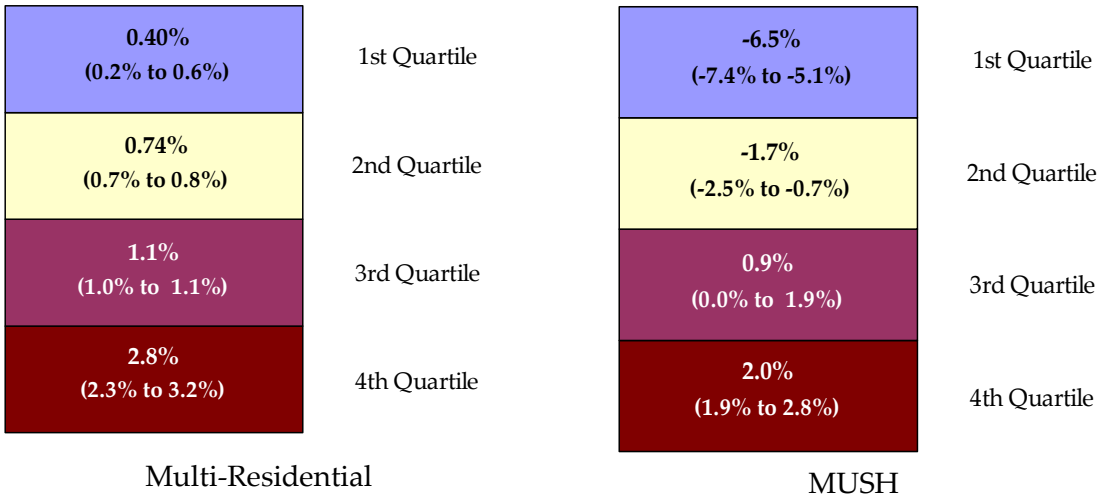
Time Period	On-Peak vs Mid-Peak	On-Peak vs Off-Peak	Mid-Peak vs Off-Peak	On-Peak vs Non On-Peak	Non Off-Peak vs Off-Peak
Ratio of Demand					
Pre-TOU	0.76	0.39	0.52	0.26	0.91
TOU	0.76	0.40	0.52	0.26	0.92
Change	0.2%	1.2%	1.0%	0.9%	1.1%
Ratio of Prices					
Pre-TOU	1.00	1.00	1.00	1.00	1.00
TOU	1.31	2.87	2.19	2.03	2.48
Change	30.8%	186.7%	119.3%	103.4%	148.4%
Elasticity of Substitution	**0.8%**	**0.7%**	**0.8%**	**0.9%**	**0.7%**

Table 13: Elasticities of substitution for MUSH participants

Time Period	On-Peak vs Mid-Peak	On-Peak vs Off-Peak	Mid-Peak vs Off-Peak	On-Peak vs Non On-Peak	Non Off-Peak vs Off-Peak
Ratio of Demand					
Pre-TOU	0.75	0.41	0.55	0.27	0.96
TOU	0.74	0.40	0.55	0.26	0.95
Change	-1.5%	-2.0%	-0.5%	-1.8%	-1.1%
Ratio of Prices					
Pre-TOU	1.00	1.00	1.00	1.00	1.00
TOU	1.31	2.87	2.19	2.02	2.48
Change	30.9%	186.7%	118.9%	101.8%	147.7%
Elasticity of Substitution	**-4.8%**	**-1.1%**	**-0.4%**	**-1.8%**	**-0.8%**

Elasticities of substitution were calculated for each participant individually, and the average of the On-Peak vs. Non-On-Peak and the Non-Off-Peak vs. Off-Peak elasticities was taken as a single measure of that participant's elasticity of substitution. The results for the multi-residential customer were reasonably consistent, varying only between 0.2% and 3.2% However the results for MUSH customers were more widely distributed, ranging from -7.4% to 2.8%. As shown in Figure 20, the average elasticity of substitution for participants in the first quartile (i.e., the most price-responsive participants) is 0.4% and -6.5% for the multi-residential and MUSH participants respectively. The average elasticity in the fourth quartile (i.e., the least price responsive participants) was 2.8% for the multi-residential participants and 2.0% for the MUSH participants.

Figure 20: Breakdown of the Customers' Elasticity Responses into Quartiles



A scatter plot of the individual multi-residential and MUSH participant elasticity plotted against their cumulative consumption is given in Figure 21 and Figure 23. This provides another perspective on the quartiles shown in Figure 20. Note that a relatively small group of MUSH participants exhibit negative elasticities of substitution (as would be expected), but also that all multi-residential and a significant proportion of MUSH participants exhibit positive elasticities of substitution (which may seem counter-intuitive).

Figure 21: Scatter plot of Multi-Residential Participant Elasticity versus Cumulative Consumption

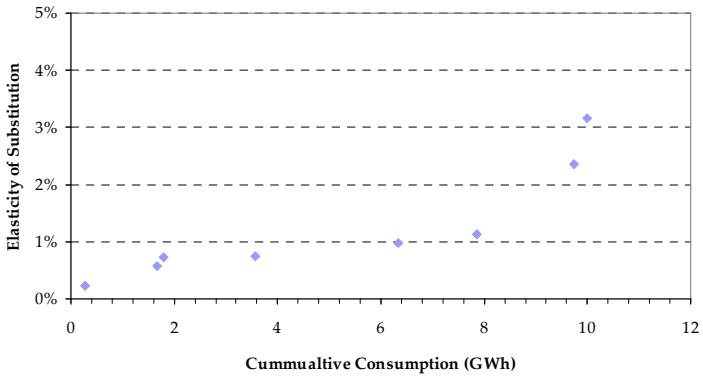
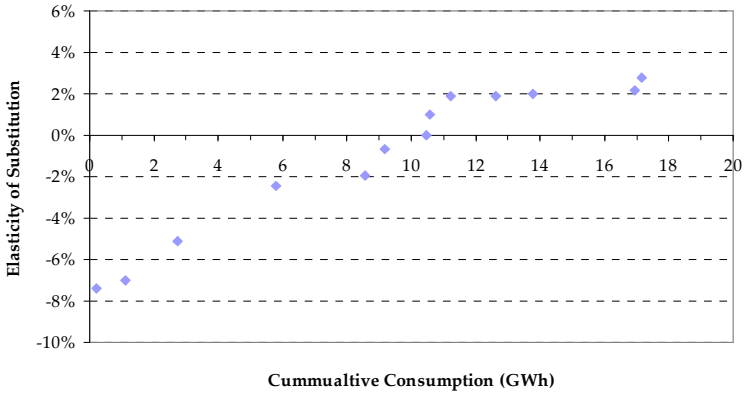


Figure 22: Scatter plot of MUSH Participant Elasticity versus Cumulative Consumption



It should be noted that the elasticities estimated in this section are short-term elasticities reflecting changes in demand over an eight month period for a relatively small number of participants. The response during such a short period is limited primarily to behaviour changes that consumers can make easily, such as changing the settings on their building controls. Over the long term, the response is expected to increase as consumers not only continue to change their own behaviour, but also invest in equipment that allows them to shift their electricity consumption from higher-priced periods to lower-priced periods.

Estimated Bill Impacts

One of the factors that is most important to consumers is how TOU pricing will affect their monthly bills relative to what they would have paid had they remained on the two-tiered RPP prices.

The bill impact was calculated for each participant by taking their electricity consumption for each month during the TOU period and estimating their commodity charge (excluding the Delivery charge, Regulatory charge, etc.) under both pricing plans: what they paid under TOU prices and what they would have paid had they remained on the two-tiered RPP prices. For the TOU price estimates, an average distribution of On-Peak, Mid-Peak and Off-Peak usage was taken for each customer based on their usage patterns during the TOU pricing (February 2007-September 2007). Since pre-TOU data was not required for this analysis, all participants with complete electricity consumption data during the TOU period were used in this analysis, bringing the total number of multi-residential participants included in the analysis to 16 and the total number of MUSH participants to 20.

The estimated bill impacts presented below are related to the way in which the tier and time-of-use prices are set under the Regulated Price Plan. Both are set so that the *average* price paid by the *average* RPP customer will be the same. Multi-residential such as those

participants analyzed in the pilot study, have consumption patterns that do not exactly match those of the average RPP customer. In particular much more of the multi-residential participants' consumption falls under the threshold: 81%, compared to approximately 50% for the average RPP customer. This difference is illustrated in Figure 23. This means that the average price paid by the multi-residential participants under tier prices would be slightly lower than the average RPP price. Furthermore, virtually all of the MUSH participants' consumption falls above the threshold, meaning that the average price paid by MUSH participants is higher than the average RPP price.

Figure 23: Consumption by Tier – Pilot Participants and Average RPP Customer

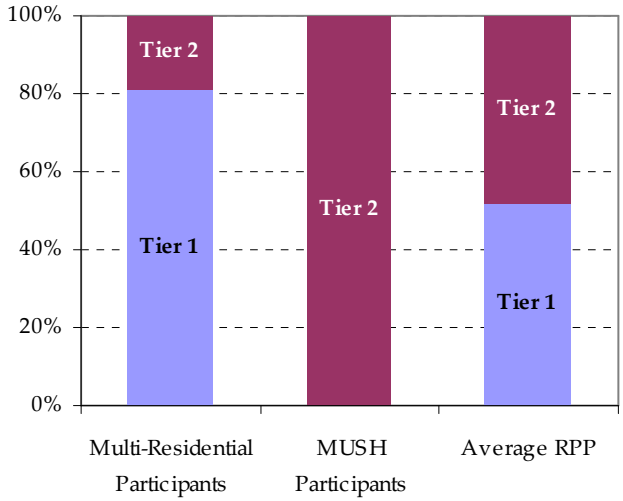


Table 14 summarizes the total estimated bill impact of TOU pricing for all the multi-residential and MUSH participants with a complete TOU dataset. As shown in Table 14 multi-residential participants paid approximately 0.05 cents per kWh more on TOU prices relative to what they would have paid under the conventional RPP tiered pricing structure, whereas MUSH participants saved approximately 0.67 cents per kWh on TOU prices.

Table 14: Estimated Commodity Cost Savings under TOU Prices

	Under Tier Prices		Under TOU Prices		Difference (TOU versus Tier)	
	Overall Cost	Average Rate (¢/kWh)	Overall Cost	Average Rate (¢/kWh)	Overall Saving	Rate Reduction (¢/kWh)
Multi-Residential	$875,378	5.56	$882,277	5.61	-$6,889	-0.05
All MUSH	$1,625,221	6.27	$1,452,122	5.60	$173,099	0.67

Taking a closer look at each individual multi-residential and MUSH participant, the average unit commodity charge for multi-residential participants was 1% higher on TOU prices, whereas the average unit commodity charge for MUSH participants was 10% lower on TOU prices. As shown in Table 15, almost all of the MUSH participants and approximately one third of the multi-residential participants experienced lower unit commodity charges under TOU prices in the pilot.

Table 15: Average Unit Commodity Charge Reduction under TOU Prices

	Multi-Residential	MUSH
Average Reduction (%)	-1.1%	9.9%
Largest Reduction (%)	8.2%	19.8%
Largest Increase (%)	7.7%	10.7%
% of Participants Experiencing Reduced Average Unit Commodity Charges on TOU Price	31%	90%

Figure 24 and Figure 25 illustrate the distribution of commodity cost reductions over the full pilot period for all each of the multi-residential and MUSH participants with a complete dataset. These figures show that the median *increase* in commodity cost for multi-residential participants is just under $0.50 per month per unit and the median *reduction* is just over $850 per month for MUSH participants.

Figure 24: Distribution of Monthly Commodity Cost Savings per Unit for Multi-Residential Customers

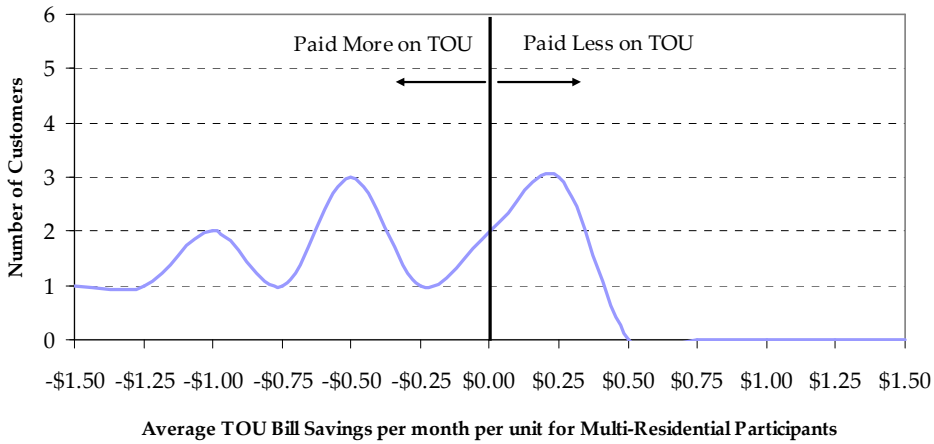
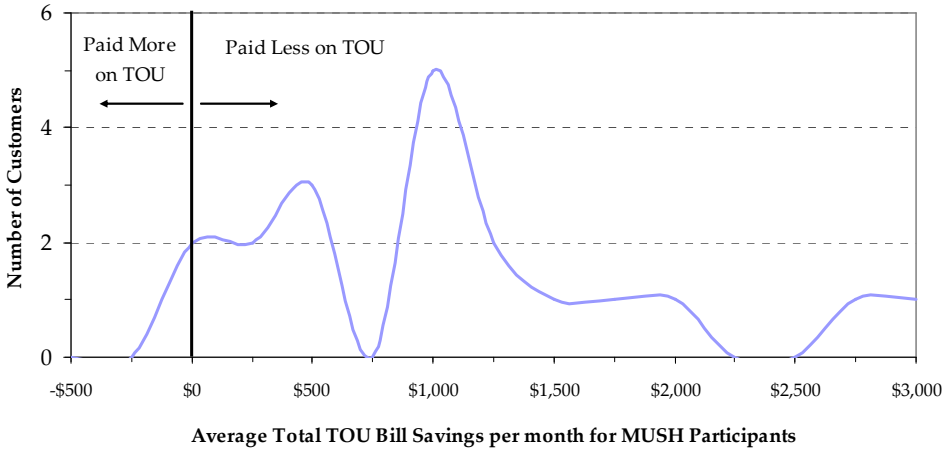


Figure 25: Distribution of Monthly Commodity Cost Savings for MUSH Customers



Note that the above analysis compares the commodity charges in the TOU period under TOU prices with what the participants would have paid for the same level of consumption under tiered prices. As discussed in *Conservation Effect* on page 16, multi-residential participants reduced their consumption by approximately 2.8% in the TOU period compared with the pre-TOU period. The combined effect of this decrease in overall consumption and slight increase in average unit commodity charges under TOU results in a slight reduction in the overall commodity costs for the multi-residential participants.

NAVIGANT CONSULTING

CONCLUSIONS

Based on Navigant Consulting's analysis of the consumption patterns of the general service customers participating in Veridian's TOU pricing pilot, the following conclusions can be drawn:

- The two customer segments participating in the pilot – multi-residential, bulk-metered customers and MUSH customers – exhibited different responses to and experienced different impacts from TOU prices.
- Based on weather-corrected (i.e., normal weather) consumption in the pre-TOU and TOU periods, multi-residential participants decreased their consumption by 2.8% on average under TOU prices, whereas MUSH participants also decreased their consumption but by only 0.1%.
- The TOU prices implemented by the Board are consistent with the Government's policy goal of all consumers paying the true cost of the electricity they consume.[12] The impact of TOU prices on the average commodity charges experienced by customers is very dependent on the relative percentage of their consumption in each of the two tiers under the RPP tiered pricing structure (i.e., the impact of TOU prices is very dependent on what customers would otherwise pay under the tiered pricing structure).
  - Over 80% of the multi-residential pilot participants' consumption in the TOU period would have been at the lower Tier 1 price. These participants experienced a slight increase of just over 1% in their average unit commodity charge (i.e., cents per kWh) under TOU prices. Note that the price these participants would otherwise pay under tiered pricing is somewhat less than the actual cost to supply them, whereas the price they paid under TOU prices was more reflective of the actual cost to supply them. Combined with their 2.8% decrease in consumption noted above, the overall commodity costs for multi-residential participants in the pilot declined slightly (i.e., 2.8% reduction in overall usage combined with a 1% increase in unit commodity charge).
  - On the other hand, almost all of the MUSH pilot participants' consumption would have been at the higher Tier 2 price in the TOU period. These participants experienced a reduction of approximately 10% in their average unit commodity charge. As with the multi-residential participants, the price that MUSH

[12] www.energy.gov.on.ca/index.cfm?fuseaction=english.news&back=yes&news_id=59&backgrounder_id=44

participants paid under TOU prices was more reflective of the actual cost to supply them.

- Multi-residential participants exhibited different price elasticities in each of the three TOU periods: -4% for consumption in the On-Peak period; -14% in the Mid-Peak period; and +7% in the Off-Peak period. Similarly, the price elasticity for MUSH participants was found to be -1% for consumption in the On-Peak period, +10% in the Mid-Peak period; and -4% in the Off-Peak period.
- The estimated elasticity of substitution for multi-residential customers ranged from +0.7% to +0.9% depending on whether the elasticity of substitution was based on On-Peak versus "Non On-Peak" (ie, Mid-Peak and Off-Peak combined) consumption or "Non Off-Peak" (ie, On-Peak and Mid-Peak combined) to Off-Peak consumption. The corresponding elasticity of substitution for MUSH participants was found to range from -1.8% to -0.8%.

It is important to note that all of the multi-residential participants in the pilot were bulk-metered. The electricity consumers in the individual units within these multi-residential facilities would have had little or no incentive to change their overall consumption and consumption patterns under TOU prices. For example, if a unit resident incurred costs to shift or reduce their usage, that resident would incur all the costs but the benefits of their actions (i.e., lower commodity charges) would be shared with all of the other residents in the apartment or condominium. This is similar to the concept commonly referred to as the "*Tragedy of the Commons*." In contrast, if the unit resident was individually-metered and billed, that resident would realize all of the benefits of their actions in the form of lower commodity charges. The Government's current initiative to install smart sub-metering systems in condominiums as set out in Regulation 442/07[13] would provide such an incentive to unit residents in condominiums.

Given that all of the multi-residential participants in the pilot were bulk-metered, the results of this pilot should not be taken as representative of what individually metered multi-residential consumers would do under TOU prices. A pilot specifically involving individually metered multi-residential consumers would be necessary to provide such information.

Note, also, that the pilot involved a relatively small number of participants and the pilot duration was only eight months. Hence, the results provided herein represent short-term impacts for a small group of customers. It would be expected that the elasticity and

[13] See the Ministry of Energy website: www.energy.gov.on.ca/index.cfm?fuseaction=electricity.smartmeters

responsiveness of customers would increase over time as their behaviour changes and they install equipment and institute operational changes that help them to take advantage of TOU prices.